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A MONTHLY POPULAR JOURNAL OF KNOWLEDGE

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THE GREAT NEBULA IN ORION
(Photo by Dr. Max Wolf)

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JOHN MURRAY, 50A ALBEMARLE STREET, LONDON, W.1.

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Editorial Notes

THERE is a tale of three eminent botanists—a Frenchman, a German, and an Englishman—who were stranded on an ocean island where there were only fourteen varieties, all told, of green plants. Fortunately, one of these was new to science; unfortunately none of these scientists knew a word of any language save his own. Such a momentous discovery (made, as it happened, simultaneously by all three botanists, since the whole island was carpeted with the flower, a species of daisy) called for deep discussion. It is said that science found out a way, and in an intricate language evolved by stringing together the Latin names of well-known flowers, the international conference unanimously decided that the flower was a daisy, but rather less so than most daisies. The tale may be exaggerated; it must be admitted that the problem of verbs must have been acute. But it serves to point a moral—that in a world where the influences which separate nations are all too many, in science and in the pursuit of what we mean by that disgraced word "culture," there are influences which work powerfully in the direction of friendship and mutual esteem.

* * * * *

In this world of unattained ideals and fruitless labours, one individual has an easy road to eminence, and that individual is the pessimist—in spite of the fact that a German author, Max Nordau, whose death occurred this year, called Pessimism the most marvellous production of the human intellect in any age. We are almost always right in prophesying, for example, that bread will fall the buttered side underneath. When we point with pride to our new London omnibus, or our latest Latin dictionary, we are sure to be reminded by Dean Inge at home or Mr. Shafer in America that we still remain human, and that therefore our buses and dictionaries are not true "progress." And when the question of internationalism arises in a general conversation, we may be certain that the speaker whose voice will be most full of conviction will be the one who foretells imminent failure and oblivion to the League of Nations and all its works. To be sure, Life is an incurable disease—it always ends in death; the cave men were our superiors, let us admit, in teeth and possibly in stone-axe manufacture; we will grant readily that Plato was a greater philosopher and a more outspoken essayist than any to-day; and finally that there have been many wars and many treaties, and that a hundred dreams of world peace have ended in disappointment. Yet we believe that the world is not chasing a bubble in its search for knowledge and its development of the world's resources; we believe that in these very pursuits lies the hope of the great ideal of international friendship.

* * * * *

Let us face again the question which Adam, doubtless, pondered as he fell asleep on his first night in Eden—what is the real aim and object of human endeavour? Dr. Johnson said that it was happiness at home; later he apparently changed his mind and said that happiness was greatest when travelling in a stage coach from one place to another. We must reluctantly assume that Dr. Johnson did not know the answer to that age-old question. Dean Inge, judging from the prominence which Eugenics assume in his *Outspoken Essays*, believes that the object of the world of to-day is to breed with discretion the world of to-morrow, and his wholesale condemnation of a great proportion of the world of to-day would leave that section without any object in living. There are a large number of people who believe that the great object of existence should be the improvement of the lot of others, and a devotion to their interests. Carried to its logical

conclusion, this attitude towards life, admirable in itself, would lead to a state of affairs where we took in each other's washing and sacrificed ourselves to others who with equal obstinacy sacrificed themselves to us—a situation which presents some difficulties and discloses little definite advantage.

* * * * *

The goal of scientific and social endeavour would appear to be a state in which the control of natural sources of energy was such that we were all fed and clothed and housed with an absolute minimum of effort and a maximum of efficiency, and were thereby set free to spend all the years of our life in the sole pursuit of our individual ideals and hobby-horses—each of us a hundredfold millionaire with all that the universe could grant at our finger-tips. No one supposes that even such an extravagant to-morrow would involve "progress" in the human mind. But the answer to all who argue that material progress is of no value is that which Mrs. Boswell gave to Dr. Johnson when he said that wealth lets nothing in. She asked, "But what does it keep out?" It is believed that Dr. Johnson was at a loss to reply. Perhaps even Dean Inge would be.

* * * * *

We have wandered a little from our botanists on the daisy-carpeted island. But if we address ourselves to considering for a moment what the scientific ideal tends to "keep out," we find ourselves quickly in their company again. There is one sphere in which internationalism is already attained. Whether or not the economic conditions of nations are mutually related (and this is fairly certain), there is no doubt whatever that we share our diseases, and that what is a scientific truth in Berlin remains true in London and even to some extent in Paris. The world of science and learning is blessed with a serenity which does not sufficiently amaze us. In the very furnace of post-war prejudice Professor Einstein came from Germany to teach such few of us as could attain to his high summit of intellect the new mysticism of Relativity. While the politicians of yesterday and to-morrow argue about the political virtues and vices of France, the whole world unites in remembering Pasteur—a name whose mention makes international squabbles seem pitifully small-minded in the light of international indebtedness. The great German pathologists, Ehrlich and Koch, have saved as many Allied lives as German bullets have wantonly sacrificed, and we, with Lister and Pasteur, have returned a like service to balance the slaughter imposed on us. There has recently been published some important work in Physics, which was based on work done in Ruhleben during war imprisonment, with the help of German scientists, by an interned civilian. In short, the domain of science is at present the one assured home of a true international spirit.

* * * * *

Among the less well-known activities of the League of Nations has been its work for international science and health. We are sufficiently close to the influenza epidemic of 1918 to remember that it destroyed more lives throughout the world than did the war itself. There exists at present an international committee to investigate the problem of world epidemics. The question of the influence of the pilgrimage of Mohammedans to Mecca in spreading plague, typhus, dysentery and cholera has been fully investigated. It is no little danger that threatens Europe, when we consider that in 1913 no less than 98,000 pilgrims went to Mecca; that these diseases were rife among them and that many pilgrims returned to Constantinople, there to meet and mix with all the nations of the world in that border-town of the East. Typhus, it is true, is a louse-borne disease, and unlikely to invade cleanly countries; but its spread westward from Russia, where it is still common, was checked by frontier precautions which almost failed when a fresh "war" broke out not long ago along that line. Finally, in these days of vaccine treatment, a huge mass of unco-ordinated work has been done in many countries on the various sera used in dysentery, tetanus, diphtheria, and other diseases. Here, too, international work is in progress to standardise methods and doses, and to share the world's knowledge.

* * * * *

In this connection allusion must be made to certain correspondence in the *Nation* of December 2 and 9, 1922. Professor Harnack, a well-known German theologian, who was last heard of by the layman when he signed the notorious letter of German professors condemning the Allied cause early in the war, wrote deploring the great injury to German culture and science done by the post-war conditions in Germany. Books are unprintable; foreign journals (in this a correspondent to *The Times* bears him out) are not to be found in reference libraries; German science is losing touch with the world. He advanced the possibility of an English subsidy. Viscount Haldane, one of few prominent Englishmen who retained an unprejudiced mind towards Germany throughout difficult years, criticised this letter; he said that science advances most through difficulties, and quoted figures which tend to show that German science is not suffering at any rate in recruits. *The Times* points out that one technical school in Germany has more than doubled its pupils since the war. It would seem that England could scarcely be called upon to help German research, even on the most liberal ideals, until it had fully subsidised its own And that day is not yet. But

the difficulties of University libraries and other institutions of like nature in keeping in touch with the literature of science is a different problem—and one which a little imagination and trifling cost in England and other lately allied countries would easily solve. And if it be not solved, it is fairly certain that the loss to the sum of human knowledge, the set-back to medical science in its arduous battle against disease, and the stifling of the humane studies and arts, will involve this tortured generation in a new offence against the ages to come.

* * * * *

We are getting superior in our attitude towards elements, but the news of another one to add to their short list is of some interest, if only to the man who, with the stamp collector's instinct, wishes to see a set complete. Two observers from Copenhagen, Coster and Heresey, announced in *Nature* of January 20 their identification of a new element which they call Hafnium. Its discovery is in some respects romantic. In 1914 H. G. S. Moseley published his investigations of X-ray spectra of elements. It was well known that each element had a characteristic line in the spectrum —that is to say that, when the element was heated to incandescence and its light analysed with a prism, dark lines on the patch of colour are typical of that particular element. This fact has enabled us to ascertain the composition of the sun and remote stars ; but a fair amount of substance is necessary to identify an element by these means. The use of kathode rays, as they are called—the bombardment of a crystal by electrons from an X-ray tube—produces an equally characteristic spectrum on a sensitive photographic plate. This method, however, is available for minute quantities of the substance investigated and is very accurate. Not only that—Moseley was able to assign to each element a number, which he associated with the number of electrons which rotate round the core of the atom. In all ninety-two atomic numbers were assigned, but there were six blanks in his list. Sir James Walker prophesied that element seventy-two, one of the blank numbers, would resemble a rare metal zirconium—discovered in 1789—in its properties. This proves to be the case, for the new element has been traced by X-ray analysis in an ore containing zirconium. Elements forty-three and seventy-five, among others, still await discovery, and it is a remarkable fact that we know nearly all about them, their properties and their weights in comparison with other elements, from the work of Moseley [1] and his predecessors without ever having seen them. It is just possible, though improbable, that they do not exist on this planet of ours. If so, fresh opportunities await, maybe, the first man to reach Mars !

[1] *Introduction to Physical Chemistry*, 1922.

What are the Nebulæ?

An Astronomical Problem

By the Rev. Hector Macpherson, M.A., F.R.A.S., F.R.S.E.

TWENTIETH-CENTURY research with telescope, spectroscope, and camera has emphasised the division of the nebulæ into several sharply differentiated groups or classes. First of all, there are the bright irregular nebulæ, of which that in Orion is the most prominent ; secondly, and closely connected with these, the dark nebulæ ; thirdly, the planetary nebulæ ; fourthly, the spirals ; and fifthly, a class of small round objects which were formerly classified with the spirals, but obviously differ from them in many important respects.

I. The Bright and Dark Nebulæ

The discovery that the bright irregular nebulæ are gaseous gave powerful support to the view that they represented "worlds in the making," the material which would be, in the course of ages, wrought into suns and systems. This, indeed, appeared to be placed beyond all doubt by the association of these nebulous masses with the so-called "early-type" stars. This association is one of the indisputable facts of stellar astronomy. Wherever there is a great nebulous region, the earlier or the blue-white types of stars are found in an abnormally plentiful quantity, and the chances are fairly strong that some of the stellar spectra will contain bright lines. On the other hand, nebulæ and red stars do not exist near each other. In recent years, however, the aspect of the question has been completely altered by the formulation of Professor Russell's theory of stellar evolution. According to this hypothesis, which has been confirmed both by theoretical investigation and observational evidence, the blue-white stars are not the youngest stars, but are suns in their prime, in the meridian of stellar life. If the blue stars are not the youngest of the suns, what, it may be asked, is the nature and function of the diffused gaseous nebulosity ?

The question has been still further complicated by one of the most remarkable discoveries of recent years—that of the second class of nebular objects—the dark nebulæ. Herschel drew attention over a century ago to several dark spots in the galactic regions which he referred to as "holes in the heavens," and Sir John Herschel detected a number of others. During the last century it was believed that these dark spots were simply regions free from stars, and it is probable that a number of them do represent vacant spaces. In 1902, however, Professor Max Wolf remarked on their symmetrical arrangement in regard to the stars

THE GREAT NEBULA IN ORION.
(*Photo by Dr. Max Wolf.*)

and visible nebulæ in their vicinity. He drew attention to a bright nebula in Cygnus, "placed centrally in a very fine lacuna, void of faint stars, which surrounds the luminous cloud like a trench. The most striking feature with regard to this object is that the star-void halo encircling the nebula forms the end of a long channel, running eastward from the western nebulous clouds and their lacunæ to a length of more than two degrees"; and he asked the question: "Is there a dark mass following the path of the nebula, absorbing the light of the fainter stars?" Dr. Wolf was gradually led to the opinion that these dark objects were not vacant spaces, but were actually composed of dark gaseous matter.

More recently Professor Barnard has published a catalogue of these objects, and there can be no doubt that they are actually great patches of obscuring material. Dr. Hubble, of the Mount Wilson Observatory, who has closely investigated these regions of obscuration in recent years, believes that the division in the Milky Way between Aquila and Ophiuchus is apparent only and is due to the presence of dark nebulosity. In a recent paper the Rev. Father Hagen, of Rome, has maintained that this dark nebulosity is much more extensive in all parts of the heavens than has hitherto been believed. At all events the bright and dark nebulæ are closely akin. In some cases, as Professor Russell remarks, "these regions of obscuration merge into faintly luminous nebulosity," and according to him, it is from these dark nebulous masses that the most youthful stars—the diffuse red giants—generally spring.

The view that stars are developed from the bright nebulæ was questioned as long ago as 1902 by Professor T. J. J. See, who suggested that "perhaps nebulosity may be expelled from the stars and does not really afford the basis out of which they are constituted," and in 1918 Professor Russell remarked on the probability that "the nebulæ as visible objects owe their existence to the radiation of the stars and are their offspring and not their parents." In a recent paper on "Dark Nebulæ" communicated in May 1922 to the National Academy of Sciences at Washington, Professor Russell shows that the normal nebula is the dark nebula—a dark cloud in space—and that the bright nebula is only a particular case. "The transition from these dark nebulæ to luminous nebulæ in the vicinity of the stars," says Professor Russell, "appears to occur in two ways. One is by simple reflection of the light of the stars," while the second is "by the excitation of gaseous emission."

This would indicate that there are two sub-classes of luminous gaseous nebulæ—a conclusion which is confirmed by actual observation. In 1914, a spectroscopic study by Dr. V. M. Slipher, of the Lowell Observatory, of the nebulæ in the Pleiades surrounding the bright stars Merope and Maia showed the spectra to be continuous—identical with the spectra of the two bright stars. The conclusion from this is that the nebulosity is inherently dark and shines by reflected light. Since then numerous other instances of this have been detected. Recent work at Mount Wilson has demonstrated the intimate relation between the types of nebular spectra and of the stars involved, and this relation, it is stated, in the most recent "Report" of the director, "demands that one be

considered a consequence of the other, or that both be due to a common cause. It suggests that one source of nebular luminosity may be found in some influence emanating from associated stars that fall within certain ranges of spectral type and hence probably of effective temperature."

In the Orion nebula, Professor Russell points out, the stars of the Trapezium appear to be the source of excitation, but he concludes that "there is no reason to believe that the luminous gas forms the whole or even any large part of the matter present within the region—only that it is selectively sensitive to the incident excitation, and therefore gives out most of the light, just as the gases (carbon compounds and nitrogen) do in the coma and tail of a comet." Bright nebulæ, then, are simply particular examples of the normal dark nebulæ which seem to constitute the primeval chaos of which the stars are born.

II. The Planetary Nebulæ

The great extended nebulæ—bright and dark—appear to be almost at rest in space. This is in marked contrast with the planetary nebulæ, whose average speed as determined by the spectroscope is about forty-eight miles per second. These "planetaries," so named by their discoverer, Sir William Herschel, from their resemblance to planetary disks, form indeed a small and select class, sharply differentiated from the other types. Like the irregular and dark nebulosities, they congregate towards the galactic plane, and they are truly gaseous, as Herschel believed them to be. But their regular contour and rapid motion, as well as their comparatively small number—only about 150 are known—mark them off as a class apart. They are almost always distinguished by the presence of a central star, so that from one point of view these may be regarded as stellar rather than as nebular objects. They are closely related to the rare type of star known as Wolf-Rayet stars, which are characterised by bright lines in their spectra. Indeed, remarked Dr. Wright, of the Lick Observatory, in 1914, "there is no escape from the conclusion that the nuclei of planetary nebulæ not only are closely related to Wolf-Rayet stars, but in many cases they are such stars." The parallaxes of six planetary nebulæ have been measured by Mr. Van Maanen, of Mount Wilson, within the last few years, and he finds the mean absolute magnitude of these stars to be + 9·1, indicating them to be dwarfs.

Dr. H. D. Curtis, of the Lick Observatory, has recently suggested that the planetaries are to be regarded as "a somewhat sporadic case in stellar evolution, arising through some collision or cataclysm and not to be regarded as cases typical of the general run of stellar development." Considerable support is to be found for this view, not only in the rarity of the planetaries and their enormous velocities, but also in the connection between such nebulæ and temporary stars. Since the application of the spectroscope by Huggins to the "blaze star" of 1866, it has been found that the spectrum of a temporary star, "or nova," passes through several well-marked stages. In every case the nebular spectrum appears at a certain period in the decline of temporary stars. The nebular stage, however, seems to be only a transient one. In 1902 Pickering found the spectrum of Nova Persei to be identical with that of a planetary nebula. Five years later Hartmann, at Göttingen, found it to be essentially identical with that of a Wolf-Rayet star. In July 1914 Adams and Pease, at Mount Wilson, found that Nova Aurigæ and Nova Persei had changed into Wolf-Rayet stars, and by April of the following year a similar transformation had taken place in the case of Nova Lacertæ and Nova Geminerum No. 2. In their paper announcing these changes, Adams and

THE GREAT SPIRAL NEBULA (× 51) IN CANES VENATICI.
(Photo by Dr. Max Wolf.)

Pease remarked that "this identity of spectrum, taken in connection with the well-known agreement of distribution relative to the Milky Way of Novæ and Wolf-Rayet stars, makes it probable that at least a portion of the latter are temporary stars in the later stages of their history." On the hypothesis of temporary stars due to Professor Seeliger, these novæ are caused by the rush of feebly-luminous stars through masses of invisible nebulosity, and the nebular and Wolf-Rayet stages may be successive stages in the passage and emergence of stars into and out of such nebulosity. Be this as it may, there is much to be said for the suggestion that the planetary nebulæ are "the wrecks of ancient novæ."

III. The Spiral Nebulæ

The problem of the spiral nebulæ has bulked very largely in recent astronomical thought. The greatest of the spirals is the great nebula in Andromeda, which was known before the invention of the telescope, but its spiral form was not discerned until after the application of photography; so the recognition of the spirals as a distinct class is due to the great Rosse reflector, and the classic instance was that of the famous object (M 51) in Canes Venatici.

About twenty years ago, after Keeler's startling announcement concerning the profusion of these objects, the prevalent view was that, in the spirals, suns and systems were to be seen forming under the eye of the observer. Indeed, the famous planetisimal hypothesis of evolution was based on the assumed gaseous nature of the spiral nebulæ. About a decade ago, however, opinion veered round to the view that the spirals were not true nebulæ at all, but irresolvable clusters at vast distances from our galactic system. In 1911 Professor F. W. Very revived the "island universe" theory, which derived considerable support from the numerous differences between the spirals and the other members of the nebular family. The average velocity of the spirals is about twenty-five times the average stellar velocity, and Dr. Shapley has remarked that as a class—"apparently regardless of the gravitational attraction of the galactic system"—they are moving away from the stellar system. Further, the discovery in 1917, on photographs of spiral nebulæ, of a number of faint temporary stars gave plausibility to the idea that such might be the novæ of distant galactic systems.

Thus the available evidence about five or six years ago seemed to point to the view that the spirals were not true nebulæ at all, but external universes which are too far away for the component stars to be separately discerned. This view seemed highly probable and indeed likely to prevail; but more recently the work of Van Maanen, Lampland, Shapley, and others has thrown grave doubts upon its validity. Mr. Van Maanen and Mr. Lampland have succeeded in measuring the motions of internal points in the nebula Messier 101. Dr. Shapley truly remarks that these measures "would indicate rotational velocities greater than the velocity of light, if that spiral is held to be even one-fifth as large as our galaxy now appears to be." Finally, Dr. Shapley points out that "if in real dimensions spiral nebulæ were analogous to our galactic system, the absolute magnitude of the novæ in spirals would far transcend any luminosity with which we are acquainted, and would be at direct variance with present results on intrinsic stellar brightness."

Accordingly, we seem compelled to regard the spirals as nebulous objects, closely connected with our stellar system. Shapley has suggested that "the spirals represent the failure to form stars from the original condensing nebulosity through the presence of too much material." On this hypothesis the spirals are composed of the unused material driven away towards the poles of the galaxy by the radiation-pressure of the stars, and would be, in a sense, analogous to the cometic and meteoric matter in the Solar System. This is not out of harmony with Dr. See's ideas that "if repulsive forces are everywhere at work expelling dust from the stars for the formation of nebulæ, it is evident that as it is repelled by the stars, it will tend to gather especially in vacant regions or spaces remote from the stars and should accumulate with maximum density near the poles of the Milky Way."[1] On Dr. See's view, however, the nebulæ are not waste material, but true nebulæ, the progenitors of suns and systems. According to Dr. Jeans, the spirals are undoubtedly such, and the "condensations" which are visible in them are the stars of the future. These enormous nebulæ, he justly maintains, cannot develop into Solar Systems, but into "streams of stars." Indeed, Dr. Jeans contends that the process of evolution is actually taking place and that its rate is to be calculated by the internal motions which Van Maanen, Lampland, and others have measured. In the case of the spiral M 101, at a distance of 5,000 light-years, Dr. Jeans finds that "this mass is, under the influence of increasing rotation, breaking up into streams of stars. Each star is of mass comparable with our sun, and the stars are generated at the rate of one every few hundred years."

The alleged extraordinary profusion of the spirals has long constituted a formidable problem. They have, for instance, been estimated to number from eight hundred thousand to a million. In 1919, however, Mr. J. H. Reynolds, the English astronomer, put forward certain objections to the view that all the small

[1] This view finds support in the theory of Professor Russell outlined in his paper on dark nebulæ.

white nebulous objects are actually spiral nebulæ. He drew attention to the existence among them of small round nebulæ "which are to be numbered by the thousand and probably actually form the majority of the known nebulæ." Confirmatory evidence of Mr. Reynolds's contention has recently been obtained at the Mount Wilson Observatory. Indeed, in the recent *Annual Report* it is stated that "the non-galactic objects which have been designated as globular nebulæ are more numerous than those of any other class. The brightest and largest of them, such as M 43, 60, and 87, show no trace of spiral structure, although their spectra and radial velocities are of the same character as those of the spirals." Mr. Plaskett, of Ottawa, has suggested that from these nebulæ the giant stars develop in accordance with Professor Russell's hypothesis.

At the present time, current theories and opinions as to the nebulæ are in the melting-pot. The advances of the last few years have enormously added to our knowledge, but have made the task of co-ordinating the known facts in a general evolutionary concept much more formidable than it was believed to be twenty, or even ten, years ago. On the other hand we have the fact that Professor Russell's hypothesis of stellar evolution fits the known data much better than any other cosmogonic theory and, further, this hypothesis points to the great dark nebulæ, of which the bright irregular nebulæ are merely particular examples, as the progenitors of the red giant stars. On the other hand, we have the fact that the evidence also favours the evolution of stars from spiral nebulæ, and further that the planetary nebulæ would also appear to be the parents of stars. At the present time, therefore, the evidence seems to point to the likelihood of there being two or three possible paths of evolution, a fact which would add meaning to the proved existence of widely different forms of nebulæ. The intensive work now being carried on at the great American observatories may be expected to throw further light upon the question within the next few years; and the apparently contradictory facts of to-day may be merged in a higher synthesis in the near future.

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*

A Test of Relationship

By R. J. V. Pulvertaft, B.A.

In 1871 a certain Arthur Orton, the son of a Wapping butcher, underwent trial for more than a hundred days on a charge of posing as the rightful heir to the Tichborne estate. A succession of witnesses were found ready to swear to his identity. Even the mother of the real heir, drowned at sea, recognised him as her son. Although Orton was fair and Tichborne dark, although Tichborne's accent was French and that of Orton very reminiscent of Wapping, there was very great difficulty in establishing the truth.

Such claims as Orton's are by no means rare in courts of law. The question of the relationship of a child to its supposed parents very often arises, as, for instance, in the Meade Divorce case settled a few weeks ago, and, again, especially when large sums of money depend on the birth of a child. And that relationship is notoriously difficult to establish. Famous artists are called upon to swear to resemblances between the shape of the parent's ear and that of the child; arguments are based on the colour of the eye and hair. But everyone realises that such arguments carry little weight; mere resemblance in feature is not convincing.

There is, however, one test which may prove reliable in questions of this sort. It was shown many years ago by Mendel, an Austrian priest, that certain peculiarities of sweet-peas were handed down in a definite manner to their descendants. In other words, a knowledge of the characteristics of the parent plants of a packet of sweet-pea seeds enables a gardener to prophesy all the possible varieties of sweet-pea which he can grow from that packet. And if those sweet-pea seeds are very crinkled, he knows that at least one of the parent sweet-peas grew also from crinkled seeds.

If we could find a single peculiarity of human beings which is handed down without any possibility of an exception, we could prove, in many cases, whether a child was or was not related to its supposed parents. We know, however, what unexpected children occur—red-haired from dark-haired parents, tall from short, and clever from foolish. Therefore none of these characteristics can fairly influence a decision—they are not "dominant" charcteristics in Mendel's phrase; they are characteristics which arise from the fact that human beings, as a recent writer[1] in Discovery has said, are "mosaics of inheritance."

As a matter of fact, there are several characteristics which are handed down from parent to child as

[1] Prof. H. J. Fleure, *Mental Characters and Physical Characters in Race Study,* in the February issue.

the property of tallness is handed down in sweet-pea families. The most noteworthy, perhaps, is a condition in which the blood of the person affected does not readily clot, and these persons run a grave risk even where a slight operation such as the removal of a tooth is necessary. This state of affairs is known as "Hæmophilia," and, although everywhere rare, is relatively common in Germany, and unknown in the tropics. Males alone are affected, but females transmit this peculiarity; before the war many of the royal families of Europe had "hæmophiliacs" among their number.

Other such conditions are colour-blindness—also more common in men than women, and transmitted through women; night-blindness, and other forms of abnormal eyesight.

The presence of any of these conditions in a child would be strong evidence of relationship to a supposed parent who also manifested the peculiarity. But all of them are rare; some of them—for example, the condition in which blood does not clot—do not appear until a child is two years old; and colour-blindness is a feature which it would be difficult to establish in a court of law. These facts render the possible usefulness of arguments based on such inherited characters rather small. We obviously require a hereditary characteristic which is common to all men, but capable of some degree of variation.

It is suggested by Dr. S. C. Dyke[1] that we have such a test of relationship in certain peculiarities of the blood. For many years it has been recognised that when it becomes necessary to transfuse blood from a healthy person to one who has lost a great deal, care must be taken lest the remedy be worse than the disease. The blood of some people is not compatible with that of others, and fatal results have occurred. Investigation shows that these accidents are due to the fact that the clear fluid of the blood of some people has the property of making the red blood cells of other people collect together in colonies.

A simple test has been devised whereby we can group individuals under one of four classes according to the reaction of their blood cells to the clear fluid of other individuals. In England a large proportion of the population comes under the same group, but as one travels east, the proportion gradually changes, until the group most strongly represented in England is least represented in India. In fact, researches have been undertaken with a view to determining the origins of nations and their varied constituent races by this test.

It appears that in these groups we have characteristics which, unlike red hair or eye colour, can really guide us to a decision on the point of parentage. For example, if both parents belong to Group 2, the children must belong to Group 2 or Group 4; if a child belongs to Group 1 or Group 3, it is not the child of these parents.

However, the application of this test is only a limited one. In the first place, one of the groups, as has been mentioned, is scantily represented in England, and this fact narrows the possibilities of the case greatly. Again, the majority of legal cases of this nature involve a position where one parent is acknowledged, and the only question concerns the other. In such circumstances the possibility of a decisive result is small. But if it proves of use in only a few cases, it will provide an answer to one of the most tangled questions which come up for decision in the courts of law—provided always that the legal mind, with its cautious prejudice against scientific proof, can be brought to accept it.

[1] *Lancet*, December 16, 1922.

Oxygen and Violent Exercise

By A. V. Hill, Sc.D., F.R.S.

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A LIVING body, even a piece of isolated muscle, is never, chemically speaking, "at rest." Apart from movement of any kind, an incessant progress of chemical change is necessary, to maintain that state of organisation of molecules, of readiness and power to react to a stimulus, which is regarded as one essential property of life. This chemical change is sometimes of an upward or constructive type in which complex bodies are made from simple ones; chemical energy can then be stored at the expense of energy from without. But at other times life is accompanied by a downward or destructive change in which the chemical energy previously stored is degraded. In the muscle of a frog, which by suitable treatment may be kept "alive" (in the sense that it will contract when excited) for as long as a month after removal from the body, there is a continual evolution of heat, a production of the gas carbon dioxide, and a utilisation of oxygen. This heat is given out at the rate of about three-tenths of the ordinary unit of heat (the gram-calorie) per hour for every gram of muscle when the muscles are kept at about 15° C., is greater when the temperature is higher, and less when the temperature is lower, being increased (or decreased) two or three times by a rise (or fall) of ten degrees. Now it is well known to chemists that the rate at which a chemical reaction goes is similarly affected by a rise or fall of tempera-

ture. There can be no doubt, then, that, whilst "resting" the isolated muscle we are talking about is undergoing the chemical change of oxidation, necessary, so to speak, to keep the fires of life burning inside the living cell.

Death and Recovery

If the muscle be deprived of oxygen it dies much sooner, but it does not die at once. The rate at which heat is produced falls to a certain amount and then remains constant for many hours. During this phase part of the substance glycogen stored within the muscle is converted into the substance lactic acid, and ultimately the muscle dies in *rigor mortis*, due to the accumulation of lactic acid. If, however, before dying it be supplied again with oxygen, the rate at which heat is produced rises not merely to its original value, but to a higher one, the excess of heat evolution making up for the deficit during the earlier lack of oxygen. The muscle in "recovering" uses not only its former income of oxygen, but also the amount that it would normally have taken during the time it was prevented. During the recovery also the accumulated lactic acid disappears and the glycogen from which it arose is largely restored within the muscle cells.

In the resting muscle, then, it is clear that two processes connected with life are occurring: (1) a process not requiring oxygen which leads to the production of lactic acid from the carbohydrate glycogen; and (2) a process requiring oxygen which leads to the disappearance of the lactic acid and to the restoration of the carbohydrate. In resting life, in presence of sufficient oxygen, these two processes appear superficially to be one, but, by first depriving the muscle of the necessary oxygen and later restoring it, it can be shown that the normal process of oxidation occurs in two stages, the initial or "anaerobic" phase and the recovery or "oxidative" phase. The first of these "sets the pace" for the whole process; the recovery phase merely follows and completes the initial breakdown.

The Function of Oxygen

By writing down chemical formulæ it is not difficult to show how the quantity of carbon dioxide produced by a muscle in presence of an adequate supply of oxygen corresponds exactly to the oxygen used, and equally whether it be lactic acid or the carbohydrate that is oxidised. These facts may be taken for granted. In the muscle without oxygen, lactic acid, as has been said, is produced from glycogen, the glycogen changing into no other chemical compound. This change is accompanied by a production of heat. In the recovery phase, however, although all the lactic acid vanishes and glycogen appears again, the change is not a complete transformation of one into the other, for a portion of one or of the other is oxidised to supply the energy lost as heat in the earlier phase. It is usual to suppose that it is a portion of the lactic acid which is oxidised for this purpose, and if this is so, we calculate that five-sixths of the lactic acid is changed into glycogen and the remainder oxidised.

The same clear division of the breakdown process into two separate phases can be detected in a muscle which is stimulated. An isolated muscle at rest in oxygen contains very little lactic acid; the more accurately the estimation be made, the less appears to be the lactic acid present. If, however, it be stimulated electrically, heat is produced, and relatively large quantities of lactic acid are formed. If the stimulation be continued, it is found that a maximum amount is eventually formed which is about 0·25 to 0·4 per cent. of the muscle's weight, depending upon conditions. If the muscle can be kept alkaline, for example, more lactic acid will be produced than otherwise. If now such a muscle be left in oxygen, the lactic acid disappears, oxygen is used, heat and carbon dioxide are formed; one-sixth of the lactic acid being oxidised, the remainder transformed into glycogen. This is exactly as in the muscle "recovering" at rest from oxygen deprivation. Moreover, other tests have shown that the chemical change in the first phase is totally uninfluenced by the presence of oxygen in any way; oxygen is used, but entirely in the second phase, the recovery. Here is, then, one of the most important generalisations of chemical and physical biology, for it is probably as true of every kind of tissue as of muscle: *Oxygen is used by the living cell only in what, properly speaking, may be called recovery processes.*

Credit and Security

The occurrence of oxidation is a necessary accompaniment of all the higher forms of life: continued activity is entirely dependent on an adequate supply of oxygen. To take an analogy from economics: business activity is always accompanied by the surrender of one's own goods in exchange for those of someone else: continued activity is entirely dependent on an adequate production of goods suitable for exchange. In most businesses, however, occasions of special need or opportunity occur, when it is necessary to incur liabilities greater than can be covered by the contemporaneous production of exchangeable goods. Here, on the "security" of other assets, not so readily exchangeable, a "credit" is obtained to meet the special need. So it is in the body. If the organs of the body were capable only of exerting activity covered by their simultaneous supply of oxygen, then that activity would be very limited, no great effort could be made, no exceptional need met

or opportunity seized. Fortunately Nature has arranged that very violent efforts can be made, that the body need not be content with its oxygen "income," but that it can obtain a "credit" for future oxygen, can (so to speak) "run into debt" for oxygen, by the agency of the lactic acid which it releases as a "security" for future oxidation. The extent of this "credit" depends upon the lactic-acid-maximum, and that depends upon the content of available alkali of the muscle tissue.

We have arrived then at two important generalisations, which appear to be established beyond dispute: (*a*) that oxidation follows, and does not accompany or precede, muscular activity; and (*b*) that the muscle, if its oxygen "income" be not adequate to its momentary need, can obtain a considerable "credit" for oxygen to be taken in later, on the "security" of the lactic acid which it liberates within itself.

Muscle as a Machine

As to the function of this lactic acid, we are on more speculative ground. It appears certain, at any rate, that the acid provides part of the mechanism of the machine, as well as the fuel to supply it with energy. In a steam engine the coal is merely there as fuel; the steam is, so to speak, part of the mechanism itself, it moves in and out in the cylinder and through the valves, it applies a force to the piston. In an internal combustion engine the gas is the fuel, its combustion provides the energy; it is, however, part also of the mechanism, it moves in and out and applies a force to the piston. In that sense the muscle resembles the internal combustion rather than the steam engine; its fuel—lactic acid—is also part of the machinery. In the internal combustion engine, however, all, or nearly all, the gas admitted to the cylinder is burnt; in the muscle, only one-sixth of the lactic acid is oxidised, the rest is restored to its original state. For another reason, however, the analogy cannot be pressed. For, although in the mechanical engineering sense the muscle is as efficient as the best gas engine ever made, it is not a heat engine. A heat engine needs a difference of temperature through which to work; a muscle is throughout at uniform temperature. The muscle acts indeed *because it changes chemical energy directly into work at uniform temperature.* In action it is really more like the combination of two dry cells and an accumulator. In lighting a lamp, or in any other work for which it is used, an accumulator runs down, the lead and the lead peroxide in it being changed into lead sulphate; in "recovery" the chemical energy stored in the dry cells charges the accumulator by restoring the lead and lead peroxide from the lead sulphate. But this analogy, too, is incomplete.

To reconstruct even in outline a physical picture of the processes which occur in muscle leads to many details of a highly technical nature. It would seem probable, however, that many of the events occurring in a muscle in action or at rest, can (or will shortly) receive a reasonable and consistent explanation, in terms of the processes of physical chemistry.

We have spoken hitherto of the isolated muscle, at rest or in activity. The same principles, however, apply to the case of a man taking exercise. It is not possible to record, without lag, the heat-production of a living human muscle; nor is it practicable to determine the lactic acid present in it. By suitable means, however, consisting of a mouthpiece, a pipe and a bag, it is easy to allow a man to inhale ordinary air of known composition and to collect all his expired air in the bag; then a measurement of its volume, and an analysis of its contents, will enable us to calculate the consumption of oxygen during even the most strenuous exercise. Many interesting results can be obtained with this method, which, although in practice somewhat laborious, is in principle simple and reliable. We will consider only a few of these.

Oxygen Consumed in Exercise

From the moment a man begins to make a violent effort his respiration is rapidly and enormously increased. At rest in bed the total air breathed per minute by a man of 70 kilos (11 stone) body-weight may be only about 6 litres (about 1½ gallons); running at 12 miles per hour it rapidly rises to 120 litres or more. This increase is not caused primarily by lack of oxygen, but rather (*a*) by the increased production of carbonic and lactic acids acting on the so-called "respiratory centre" in the nervous system, and (*b*) by other less tangible nervous influences due either to consciousness of the effort or to reflex action caused by it. The rate of oxygen consumption, however, rises rapidly if the exercise be continued. Starting at (say) 200 c.c. per minute when at rest, it rises to a certain maximum value, characteristic of the violence of the exercise, attaining this maximum to all intents and purposes within two or three minutes. The more severe the exercise, the greater is the final maximum rate of oxygen-consumption associated with it; beyond a certain limit, however, the mechanism for supplying the oxygen fails; in other words, the lungs, blood, heart, and arteries have attained their maximum activity, and no greater supply of oxygen can be secured, however much it be required. Consequently, in all forms of violent exercise, after a certain limit the body has to "go into debt" for the oxygen it needs, over and above the amount it can obtain at the time through the usual channels. This oxygen it takes in later, after the exercise has ceased

or slackened. Everyone knows that severe exercise is not only accompanied, but followed, by severe respiration, and in this subsequent "recovery process" considerable quantities of oxygen are taken in; indeed, recent experiments in Manchester by two colleagues of mine (Messrs. Lupton and Long) have run this "recovery oxygen" up to 10 litres, enough to maintain a man in bed for nearly an hour! Actually, of course, a man cannot lie in bed without oxygen for an hour; his brain and heart require a continual supply of oxygen. But it is a striking fact that by severe exercise lasting for less than a minute a man may incur a debit balance of oxygen which would be sufficient to keep him comfortably in bed for about an hour. Looked at in another way, 10 litres of oxygen cannot be supplied through the circulation in less than about 2½ minutes, even with the most violent respiratory effort. Thus in less than a minute it is possible to incur a debt which it will take one's heart and lungs 2½ minutes to repay, even when working at their hardest; for a short time one may expend energy several times as fast as one could possibly do if one were dependent on a simultaneous supply of oxygen. *These facts illustrate the advantage to the body of the latitude allowed by the system of paying later on for its efforts in the immediate present.*

Athletic Records

Let us now consider some world's athletic records, and the conditions affecting them. The Amateur Athletic Association, I believe, "passes" records made upon the track; the Physiological Society ought to undertake to "pass" records made in the laboratory! There are two quantities in which the world's records are of fundamental physiological interest: (*a*) the maximum oxygen debt which it is possible for a man to incur, and (*b*) the maximum intake of oxygen per minute during severe exercise. Both, properly speaking, should be reckoned per kilogram of body-weight, though this has not been done here. Both records are held by members of the University of Manchester, one by a Professor and the other by a Bachelor of Science. It might advance physiological knowledge were Oxford and Cambridge to give a "full blue" to oxygen-intake representatives, and a "half blue" to those able to incur the greatest debit balance (of oxygen); such contests might even be included in the Olympic Games. It is quite certain anyhow that the Professor and the Bachelor of Science will soon be ousted from their present proud positions as holders of world's records.[1]

[1] The Professor's record still stands, but the Bachelor's record has been beaten by over 3 litres, by a Y.M.C.A. sportsman of forty-six years.

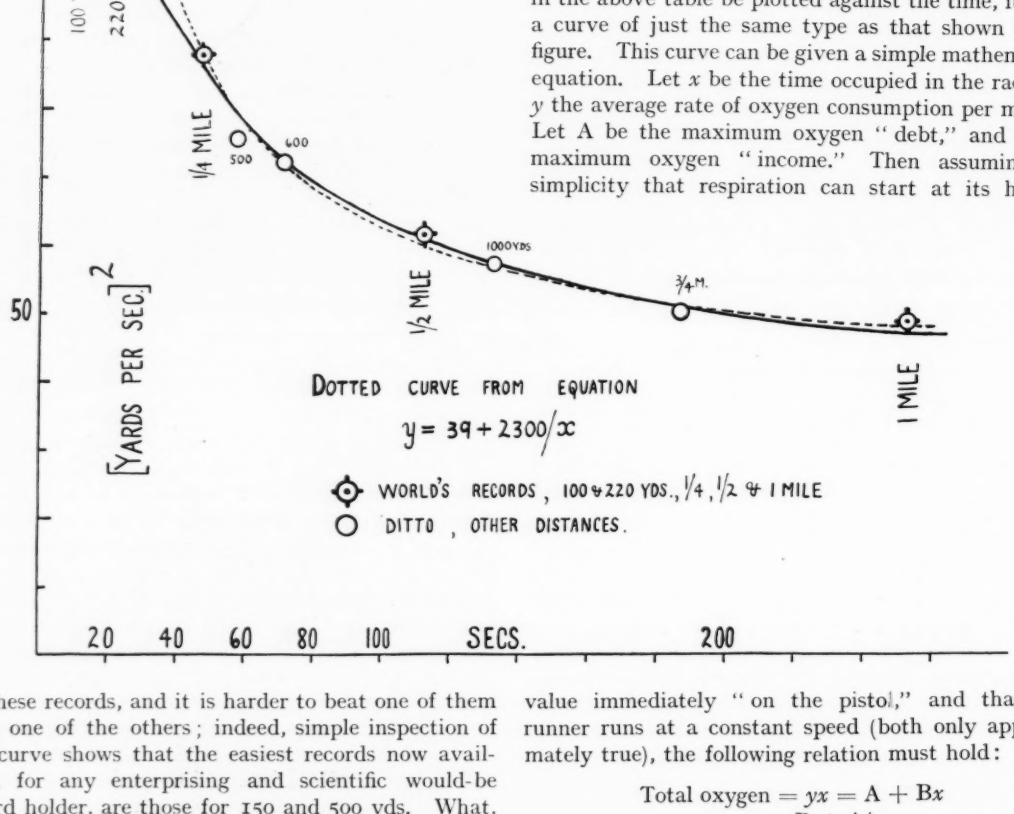
Let us consider what these records mean. The Professor, who weighs 73 kilos, has managed, by vigorous running, to utilise 4,175 c.c. of oxygen in a minute. Assuming 1 c.c. of his arterial blood to contain about 0·185 c.c. of oxygen—the normal amount—and 1 c.c. of his mixed venous blood to contain about 0·650 c.c. of oxygen—it could not have contained much less—then every 1 c.c. of his blood, as it travelled round his body during the exercise, must have lost 0·12 c.c. of oxygen. Thus to take in 4,175 c.c. of oxygen it must have required about 35 litres of blood to pass through the heart and lungs per minute—a mass of blood equal to that of half the body every minute! There are few water taps which will turn out 35 litres (9 gallons) every minute, and yet the heart can do it, probably in a first-class runner for an hour on end; it is small wonder that the heart is one of the parts most likely to fail when the machine is overloaded. Of course there are not 35 litres of blood in the Professor's body—probably only about 5—so that the whole of it has to circulate seven times every minute.

The record held by the Bachelor of Science is 10 litres; by extremely violent jumping over a stool in a cellar (strange things happen in physiological laboratories) he produced fairly complete exhaustion, and in the succeeding 10 minutes took in 10 litres more of oxygen than he would have needed had he remained at rest. He must have produced not far from the lactic-acid-maximum in his muscles. Now these two gentlemen are admittedly world champions only on false pretences; merely because no first-class athletes have tried to oust them from their championships. There can be little doubt that W. G. George in his prime, or even our present-day mile champions, could put up a record of at least 5 litres per minute for the intake, while a half-mile champion "run out" to the last ounce could probably incur an oxygen debt of at least 15 litres. This is prophecy; but, were betting not forbidden by the rules of the A.A.A. (if not, at present, by those of the Physiological Society), I should be prepared to back the prophecy with cash!

The Limit of Speed

Let us now consider some further world's records—the times of the flat races from 100 yds. to a mile. Suppose a man to run on the level at a constant measured speed, and let us determine the value of his oxygen consumption *per metre travelled*. We all know that it is a greater effort to run 100 yds. fast than to run it slowly, and it is found that the oxygen consumption increases with the speed. Indeed, the oxygen needed *per metre travelled* is approximately proportional to the *speed*. Hence, the oxygen needed *per minute* should be approximately proportional to

the *square of the speed*. In the figure are shown the world's records, taken from *Whitaker's Almanack*, of flat races from 100 yds. to 1 mile. Horizontally are plotted the times occupied in the race, vertically the squares of the average speeds at which the record was made. The curve joining the points is a fairly smooth one, though it is noticeable that the principal records (100 yds., 220 yds., $\frac{1}{4}$, $\frac{1}{2}$, and 1 mile) lie rather above the curve as a whole. More effort has been expended



on these records, and it is harder to beat one of them than one of the others; indeed, simple inspection of the curve shows that the easiest records now available, for any enterprising and scientific would-be record holder, are those for 150 and 500 yds. What, however, is the cause of the general form of the curve? It is simple to show that, apart from one factor, the principles we have discussed above (of oxygen "income" and oxygen "credit") provide a satisfactory general explanation.

In the first place, the reader will notice that, in the figure, we have plotted the *square* of the average velocity; as we have pointed out above, this quantity is proportional approximately to the rate of oxygen consumption per minute, so that in effect the figure gives approximately the relation between the rate of oxygen consumption (*not* supply) and the time occupied in the race. Now if the maximum oxygen "income" of a world's-record-holder be 5 litres per minute, and his maximum oxygen "credit" be 12 litres, then in various times he can take exercise equivalent to the following quantities of oxygen:

Time: minutes . .	1	2	3	4	5	10
Total oxygen available: litres	17	22	27	32	37	62
Oxygen per minute: litres .	17	11	9	8	7·4	6·2

We see that the oxygen available per minute is much less in a long race than in a short one; hence the speed must be less too. Indeed, if the oxygen per minute in the above table be plotted against the time, it gives a curve of just the same type as that shown in the figure. This curve can be given a simple mathematical equation. Let x be the time occupied in the race and y the average rate of oxygen consumption per minute. Let A be the maximum oxygen "debt," and B the maximum oxygen "income." Then assuming for simplicity that respiration can start at its highest value immediately "on the pistol," and that the runner runs at a constant speed (both only approximately true), the following relation must hold:

$$\text{Total oxygen} = yx = \text{A} + \text{B}x$$
$$\text{or} \quad y = \text{B} + \text{A}/x.$$

In the figure an equation of this type, represented by the broken line, is shown to fit the curve with reasonable accuracy. It is noticeable, however, that at short times the relation does not hold at all. The reason is obvious. In the shorter races it is impossible to exhaust all the oxygen available, even in the most violent effort; the limit is imposed here *not by the oxygen supply, but by the sheer capacity of the muscle.*

There is one fundamental weakness in the data used

in drawing the figure, viz. that all these records were made by different persons, presumably with different A's and different B's, i.e. different "credits" and different "incomes." It is hoped, by consultation with, and experiments on, a number of good athletes, to draw up a standard average curve of the same type for (say) a good mile runner, running all distances over the range considered. A good 100-yds.-runner usually cannot, or will not, run a mile at all! Moreover, by a series of experiments on such athletes, it should be possible to make a reasonably accurate statement of the real relation, at all speeds, between the rate of oxygen-consumption and the speed. The former is certainly not exactly proportional to the square of the latter. For the present, however, it would seem that the general principles are correct, and that the speed and power of human muscular effort are mainly limited by considerations of oxygen "income" and "credit." The further exact investigation of these facts will add greatly to the scientific interest of athletics, and so will bring another valuable source of experiment and observation within the reach of those who are studying human function and activity. It is not contended that these considerations of oxygen and energy are the only ones; there can be no question of the importance of technical skill and training in the use and correlation of one's muscles and limbs, of tactical judgment in the actual race or effort, and of the mental and moral aspects of what athletes call "guts," that most intangible and yet most certain aid to athletic success or bodily prowess. Neither can any one of the physiological functions of the body be left out of account. Given all this, violent muscular effort still consists mainly in the degradation of energy, and this aspect of it gives us the clearest and most definite picture of its essential nature.

Garibaldi's Bride of an Hour—A Postscript

By Thomas Okey, M.A.

Professor of Italian in the University of Cambridge

[The interest aroused by Professor Okey's narrative in the last number of DISCOVERY of this hitherto almost unknown episode in Garibaldi's life was very considerable. In this small postscript Professor Okey offers to our readers two photographs of the remarkable woman who acted as a messenger for the Garibaldians, nursed the great hero, and married him, only to be deserted by him within an hour after the ceremony. On whose side lay the greater degree of blame for the tragedy is a question which will probably never be decided.—ED.]

OWING to the good offices of Signorina Emma Bellati, and through her friends in Italy, I am enabled to offer to the readers of DISCOVERY copies of two existing

photographs of *la bella Giuseppina*. The sitting, full-figure is the nearer, as may be easily seen by the dress, to the period of the Garibaldi drama. The

photograph was taken at Zurich, and is the property of a friend of the family. The second portrait, taken later at Milan, admirably portrays, according to one

who knew her well, the singular charm, beauty, and goodness of Donna Raimondi's personality—a nature, sweet, generous, and kind, which won the sympathy and affection of all who had the good fortune to meet her. Among the common people she was beloved to the end of her days.

This second portrait is of historical interest. When Donna Giuseppina fled from her father's villa after the stormy scene with her bridegroom in the garden, she rook refuge at the factor's house at Gironico, where she was sheltered and caressed by his wife during those heart-breaking and sorrowful days. To this friend in need Donna Raimondi, in token of her enduring gratitude, gave the photograph here reproduced.

Between the Covers

RACIAL VARIETIES IN OUR POPULATION

METHODS of living, types of speech, mannerisms are not the only forms in which the difference in racial stocks between one county and another, and often between one village and another, proclaim themselves to him whose business takes him continually from one district to another in England. In his newly published book, *The Races of England and Wales* (Benn Bros., Ltd., 5s.), Professor H. J. Fleure has summarised the main conclusions of recent research on an intensely interesting subject. After dealing with the origins of our population and the minglings of various racial stocks, the author outlines the variations in the physical appearance of the inhabitants of different English counties.

"There is no doubt," he says, "that in every part of England and Wales several types live side by side. Often, certain types are found only as rare exceptions, occurring in perhaps 1 per cent. of the population or less, but there are usually places where these, generally rarer, types occur in considerable numbers, perhaps making 20 or 30 per cent. of a sample. It is from evidence such as this that we are forced to gather our points as to the distribution of physical types in Britain."

As most of us know, the population of Northern and Eastern England is predominantly fair in colouring, and is characterised by its "long heads, straight profiles, fine noses, grey eyes, and fair hair." This is probably due chiefly to Scandinavian and Danish origins.

To cite a few examples. "The Yorkshireman of the north and east is not only generally fair and long-headed, but also tall and well built. . . . In remoter corners, however, especially towards Derbyshire, the darker types are much more numerous, though in the Derbyshire dales we again find numbers of the Beaker [1] type.

"In Cumberland and Lancashire fair long-heads are abundant enough, but the little dark long-head is also well marked in the latter. . . . Beddoe found the North of England and Derbyshire about the fairest region of the whole country. . . . Lincolnshire, again, is strikingly fair. . . . East Anglia has more constrasted types. . . .

"The Midlands obviously retain a larger element of the old stocks than do the north and east; they were of old densely wooded and were cut off from East Anglia by great marshes. Beddoe was probably right in thinking that the Vale of Aylesbury and East Worcestershire, both areas of fertile land early occupied by Saxons, have a rural population fairer than the average of the Midlands. . . .

"In the south, Kent has tall, fair long-heads in large numbers, and so have Surrey, Sussex, and Hampshire; but in the Romney Marsh, the Weald, and the north of the New Forest are pockets of darker types of older standing.

"As one goes west, either in the Midlands towards the Welsh border, or in the south towards the border of Wilts and Somerset or Dorset and Devon, the numbers of dark-haired people seem to increase, the older breeds become more conspicuous. . . .

"Devon appears to show much dark hair with grey eyes. . . . Cornwall has the darkest population in England, with dark long-heads thickly distributed, but also the stalwart dark broad-heads who are found in nearly all the fishing harbours."

AN AMPHIBIOUS TANK

A new type of military tank has caused much interest in the United States. Its "paces were tried out" not long ago before officers of the War and Navy Departments, and members of the American Society of Mechanical Engineers.

"The tank," says the *Scientific American* for February, "was driven on the level road at a speed of 25 miles an hour; climbed a slope of 40 degrees at the foot of the Palisades of the Hudson. Returning to the bank, it moved down into the water, and, against a strong tide, crossed the river where it is nearly two miles in width, under its own power."

Its body consists of a plate-steel watertight structure. For road work it "runs upon solid rubber-tyred wheels. At the rear end of the tank is an extra pair of wheels

[1] So-called on account of apparent descent from immigrants who came into Britain from across the North Sea towards the close of the later Stone Age, and whose graves can be identified to-day by the presence of the so-called "Beaker" pot—a feature of the culture that they brought with them into Britain.

which, when the tank is running on the road, are sufficiently raised to clear the surface."

For cross-country work this remarkable vehicle is equipped with caterpillar chains, and for crossing water two propellers are "attached to the shafts which project from the rear of the under-water body, power being obtained from the motor."

PSYCHO-ANALYSIS AND M. COUÉ

"In the early stages of psychological medicine the chief stress was laid on suggestion, of which hypnotism was the most striking form. Faith and suggestion are still the prominent agencies in most lines of psycho-therapeutical treatment. It is altogether to them that are due any beneficial results which may have come from the sensational methods of Coué, of which so much has been recently heard, and those processes form the basis of much of the treatment methods practised to-day. It is now one feature of these two processes and of methods founded upon them that they make no attempt to reach the root of the disorder, in the treatment of which they are applied; but their advocates are content to treat the outward and obvious manifestations usually called symptoms.

"When M. Coué tells his devotees to say that their pains are growing less and their appetite greater every day, he makes no attempt to discover the causal factors upon which the pains or the diminished appetite depend. Using the language of ordinary medicine, the treatment is purely palliative. The main principle of modern medicine is that, if symptoms only are treated while the cause of the symptoms is left untouched, the trouble will probably recur sooner or later, perhaps even in far more troublesome guise than that for which the palliative remedies were originally applied. The second main line of treatment is that which recognises this principle and makes it its chief business to discover the nature of disorder, one often dating back for many years, through whose activity the symptoms are produced. Its object is that the sufferer shall come to understand the faulty trends by which his disorder has been produced, and by such self-knowledge shall see where his life has left the normal path and how his steps can again be set upon the path of health. It is this process which is denoted when the physician speaks of the process of re-education."—The late Dr. W. H. R. Rivers in "An Address on Education and Mental Hygiene" included in his recently published book, *Psychology and Politics*. (Kegan Paul, 12*s*. 6*d*.)

A REMARKABLE ATMOSPHERIC PHENOMENON AT SEA

The January number of *The Geographical Journal* contains a problem-raising note on a letter written to the Editor by Dr. A. Birnham-Smith describing a phenomenon witnessed by the latter and other persons on board the s.s. *Eden Hall* in the Persian Gulf fifteen years ago.

"It was dark at the time, with a very glassy sea, when it suddenly appeared as if someone was turning flashlights on the ship (which was not provided with electric light). It turned out to be waves of light wheeling round the ship in the air just over the sea, and not actually on the surface. The phenomenon was observed for twenty minutes by all on board. Although, as we have said, the appearance seems to be an unusual one, a very similar phenomenon was reported in 1909 by the master of the Danish East Asiatic Company's steamer *Bintang*, Captain Gabe, as seen in June of that year during the passage through Malacca Strait, and a printed description was afterwards issued by the Danish Meteorological Institute, with an illustration. In this case the phenomenon is said to have resembled a revolving light, with a pretty fast rotation, the light-waves taking the form of long arms issuing from a centre which seemed to lie on the horizon. Inquiries instituted with a view to learning whether other observations of such a phenomenon existed at first met with negative replies, but eventually the report of a similar experience was obtained through the Dutch Meteorological Institute from Captain Breyer of the Dutch steamer *Valentijn*, who in 1910 observed the phenomenon near the Natuna Islands in the South China Sea."

New Methods of Judging Musical Ability

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CAN psychological investigation throw any light on the nature of the musical mind, on the problem of what makes up the difference between the musical person and the person who, in spite of all his efforts, remains incapable of musical performance and appreciation? This is a problem which has been attacked by Professor Seashore, of the University of Iowa. His results have interest both for the teacher of music and for the student of psychology.

The method of dealing with such a problem as this is, first, to analyse the complex function of musical talent into simpler elements; secondly, to devise methods of testing separately the ability of different individuals in each of these simpler functions. We ask, for example, why one person learns to play and

sing easily, while another seems incapable of learning to do either. It may be because the second person is incapable of discriminating between small differences in pitch, that is, degree of acuteness of tone, or he may be unable to remember music, although he hears it as accurately as the other, or he may be unable to sing because he cannot control the tension of his vocal chords. These—power of pitch discrimination, tonal memory, and control of the pitch of the voice—are examples of the simpler elements into which musical ability may be analysed.

Elements of Musical Talent

Professor Seashore repudiates the idea of the existence of any one "musical faculty," and analyses musical talent into twenty-five such simple elements. These are the following:

I. Musical sensitivity.
  A. Simple forms of impression.
    1. Sense of pitch.
    2. Sense of intensity.
    3. Sense of time.
    4. Sense of extensity.
  B. Complex forms of appreciation.
    1. Sense of rhythm.
    2. Sense of timbre.
    3. Sense of consonance.
    4. Sense of volume.

II. Musical action.
  Natural capacity for skill in accurate and musically expressive production of tones (vocal, instrumental, or both) in:
    1. Control of pitch.
    2. Control of intensity.
    3. Control of time.
    4. Control of rhythm.
    5. Control of timbre.
    6. Control of volume.

III. Musical mĕmory and imagination.
    1. Auditory imagery.
    2. Motor imagery.
    3. Creative imagination.
    4. Memory span.
    5. Learning power.

IV. Musical intellect.
    1. Musical free association.
    2. Musical power of reflection.
    3. General intelligence.

V. Musical feeling.
    1. Musical taste.
    2. Emotional reaction to music.
    3. Emotional self-expression in music.

Six of these investigations are of particular practical interest, since they can be repeated without special apparatus. These are the tests for: *sense of pitch, sense of intensity, sense of time, sense of consonance, musical memory,* and *musical imagery.* The first five of these are supplied on gramophone records. Full instructions as to Professor Seashore's method of carrying out the last are to be found in Chapter XI of his monograph.[1] By the use of these tests in schools, it is claimed that the teacher is enabled to detect those of his pupils who are deficient in the simple qualities which make up musical talent, and also to distinguish those especially gifted ones who may develop exceptional musical ability if they are given separate training.

The method of representing the performance of any individual in a given test is by his percentile rank, i.e. by his probable position in a group of a hundred unselected persons whose order is that of their proficiency in the ability tested. For example, a person who has 50 per cent. right in the pitch discrimination test will have a percentile rank of 0,[2] a person with 100 per cent. right will clearly rank as 100. The percentile ranks of persons who have between 50 per cent. and 100 per cent. right answers is given by tables based on the results of a large number of previous applications of the test. A person with 90 per cent. right is found to stand eighty-sixth in his power of pitch discrimination in a chance group of a hundred; with 60 per cent. right he would stand only third from the bottom.

How to Test a Person's Sense of Pitch

Limitations of space make it impossible to discuss all twenty-five of the researches into these elementary capacities, so I will be content to describe in detail one only—the investigation of the sense of pitch. The pitch of a musical note depends on the number of vibrations per second of the sound waves producing it, the higher notes being produced by the sound waves with a large number of vibrations per second. The problem, therefore, is to discover by how many vibrations per second a given note must be altered before the person who is being tested can distinguish between them. For this purpose, a standard tuning-fork and one differing slightly from it in pitch were sounded in quick succession, and the subject was required to state whether the second tone was higher or lower than the first. Different intervals of time between the two forks were used, and an individual's power of discrimination between two tones was taken to be the interval of time between the standard and variable

[1] Referred to in note at end of present article.

[2] Because 50 per cent. is the number he would have right if his answers were determined by chance alone, i.e. if he had no power at all of determining which of the two notes sounded was the higher.

fork for which he gave 75 per cent. right answers. Very great individual differences were found; one person could perceive a difference of a quarter of a vibration per second, while another could only distinguish two notes in the same position in the scale if their pitch difference was fifty vibrations per second. Thus in this capacity the best person tested was two hundred times better than the worst—a remarkably wide range.

An Untrainable Faculty

The importance of this ability to discriminate pitches, both for the performance and for the appreciation of music, can hardly be questioned. It is therefore not surprising to find that in an examination of members of the Royal Opera in Vienna by Stücker, a very fine power of pitch discrimination was discovered, ranging from ·1 to 1·1 vibration per second for the A above middle C.[1] The question, however, which immediately raises itself in the mind is whether this finer pitch discrimination in musicians and singers is due to their training or whether it is inborn. In other words, has a man fine pitch discrimination because he is a practised musician, or has he become a musician (partly, at least) because he had a fine power of pitch discrimination from the first. If the former alternative were true, the measure of pitch discrimination would reveal musical training and not musical talent. From evidence drawn from a variety of sources, Professor Seashore concludes that the ability to discriminate pitch is innate, and is not affected by training. No material difference is found in the pitch discrimination record of a pupil after he has entered on a musical training, although such observations have been made for several years. Nor does this power increase with age. A group of children show the same distribution of the capacity as their parents.

While sensitive pitch discrimination seems to go hand in hand with spontaneous evidence of musical interest in children, it seems to be practically unrelated to the tendency to give them musical training. In other words, a child with a finely discriminating ear is no more likely to receive musical training than a more ordinary child. This may not be altogether wrong for two reasons. First, it must be noticed that pitch discrimination is not the only factor which makes up musical talent, and all the other factors must be taken into account in deciding what children are suitable for musical training. Secondly, although high musical achievement probably necessitates fine pitch discrimination, something less even than the normal fineness of discrimination is enough for most of the purposes for which musical education is ordinarily acquired. The fact that he can never be a first-class singer does not mean that a child will gain no benefit from an education in music.

[1] Professor Seashore, however, throws doubt on the lowest of these figures.

Other Tests

The other investigations followed similar lines, with such differences of experimental method as their different problems required. For testing the sense of intensity, two notes were sounded successively, and the subject was required to say which was the louder. Similarly, for the sense of time, three successive taps were made, and the subject was required to state whether the interval between the second and third was equal to, greater than, or less than, that between the first and second. In the test for sense of consonance (sounding of two notes in harmony) two chords were sounded successively, and the subject was required to give a purely æsthetic judgment of which of them appeared to him to be the more pleasing. The musical memory test is a more elaborate one. A series of notes ranging in length from two to six is sounded twice, one note being altered for the second time of sounding. The subject is required to say which note is different in the second sounding. This test appears ridiculously easy to a person with fairly good musical memory, but other persons find it difficult or impossible to detect the note altered in the longer series. The investigation of auditory and motor imagery follows the general lines of Galton's famous *questionnaire*,[2] but it is more detailed. It is, I think, open to the criticism that in giving six degrees of vividness of images of all kinds it introduces a false appearance of exactness. Other more objective tests of imagery have been discovered since Galton's time, but these are less easy to apply.

The value of such an analysis can be tested by the musical ability which the individual shows in other ways. Such a correlation has been shown by Professor Seashore to exist. He gives as examples three cases taken from a collection of 308 university students. Mr. White ranked between 90 and 100 in sense of pitch and consonance, keenness of hearing, memory, singing key, and register of voice, and his worst record—in motility (capability of motion)—was over 60. Although he had had little formal training, he showed great interest and activity in music, and was emotionally responsive to it. Mr. Black ranked 10 or less in such important factors as sense of pitch, time, and consonance, and also in auditory imagery, so although he was better in relatively unimportant factors, such as sense of intensity, he might reasonably have been expected to be decidedly inferior in musical talent. This was the case. He had taken music lessons, but met with failure, and had little interest in music.

[2] *Inquiries into Human Faculty*, by F. Galton. Appendix E.

Mr. Gray, who ranked well above the average in some factors (sense of pitch and keenness of hearing), and well below in others (sense of intensity, sense of time, and sense of consonance), had average musical ability. With little musical education, he possessed an artistic type of mind and lived much in musical feeling.

Value of These Investigations

It may be urged in objection to this kind of investigation that the possession of all the simple functions described—sense of pitch, sense of time, etc.—does not in itself make a musician. Something more than these must be supposed to be necessary to make up the difference between a Pachmann and a merely mechanically accurate performer, and this something may elude psychological analysis. This is probably true. We could not even give an account of what makes a champion tennis player, apart from such physical qualities as strength of wrist and arm, accuracy of co-ordination of hand and eye, etc. Two players may be equal in all these respects, and while one remains a good, but not very good, match player, the other may become English champion. What makes the analysis and investigation of these simple factors in musical ability much more important than the corresponding physical measurements of tennis players is their more elusive character. No one is likely to start training as a tennis player if he is blind, or club-footed, or has lost the use of his right hand. Yet a precisely similar error is constantly being made when money and time are wasted in giving children musical training who are totally deficient in one of the unitary factors which are necessary for any musical success at all, such as the sense of pitch or the possession of auditory imagery. If blindness and club feet were defects not immediately apparent on inspection, we would have reason to be grateful to anyone who discovered a way by which these defects could be detected otherwise than by the wasteful process of teaching tennis to all children and only discovering that they were blind or lame by the failure of prolonged attempts to teach them the game.

Dr. Seashore has, however, done more than this. His analysis of the factors which make up musical talent is in itself a great advance in the theory of musical ability. His list of twenty-five factors is a welcome recognition of the complexity of a condition which is simply explained in popular speech by the phrase: "He has no ear"—a phrase which assumes that the only difference between the musical and the unmusical person is that the latter is deficient in his power of discriminating pitches. How untrue this is can be proved by anyone who cares to experiment on the subject. I have myself found in a single test one person of exceptionally high and one person of exceptionally low musical ability, who showed exactly the same rating as each other in pitch discrimination.

Can the More Elusive Factors in Musical Talent be Analysed ?

The presence in musical talent of factors which so far elude psychological analysis is indicated by the complex character of the later functions investigated by Professor Seashore. Musical taste is not an elementary function like pitch discrimination. Perhaps it is one which may be further analysed, even although it may be impossible to split it up into really simple constituents. Such further analysis belongs to a branch of experimental psychology which may be called experimental æsthetics.

As an example of the investigation of these more elusive factors in musical talent, I will mention shortly some experiments performed by Dr. C. S. Myers on individual differences in listening to music. He used fifteen subjects of various degrees of musical appreciation, and obtained from them introspective reports of their impressions and mental attitudes while they were listening to music produced by means of a gramophone. It is impossible to give even a short summary of the results of such work as this. These investigations have been mentioned here only to illustrate the fact that experimental inquiry need not stop at the investigation of simple functions, although as it approaches more complex problems it must adapt its methods to their requirements.

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Substances Existing in Various Forms

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EVERYONE is familiar with the fact that substances are, in general, capable of existence in more than one form. For example, the substance known as water may exist as ice, liquid water, or steam. We have thus become accustomed to classify the various states of aggregation of matter—that is, the different ways in which units of matter may be grouped together—as the solid, the liquid, and the gaseous states. This classification is, however, incomplete. There is usually

more than one variety of the solid form of a substance, and cases are also known in which varieties occur in the liquid and gaseous states.

Newton observed the high specific gravity and the power of refracting rays of light which the diamond possessed, and ventured the opinion that it would prove to be combustible. Inconclusive experiments on the subject were made by the older chemists, but the true nature of diamonds was first discovered by Lavoisier, a French chemist, who burnt them in oxygen, and found they yielded carbon dioxide—the same product as is obtained by the burning of charcoal. A few years later it was found that graphite—the substance from which pencils are made—when heated strongly with nitre, was also transformed into carbon dioxide. Diamond, charcoal, and graphite are therefore varieties of carbon, and are termed "allotropes."

Allotropy may be defined as the phenomenon of the existence of elements in more than one modification. However, not only elements, but also compounds containing two or more elements, show a similar disposition to exist in a variety of forms. Calcium carbonate, for example, occurs in nature as two completely different crystals, known respectively as Iceland spar and aragonite. The term "Polymorphism" had been employed to characterise this property of variation in the form of crystals of a compound, and implies a property in compounds similar to that which we have described in the case of the element carbon.

It has been known for many years that a variety of oxygen can be obtained by the action of electric discharges on the gas, which is endowed with much greater chemical activity than ordinary oxygen. This active variety of the gas is termed ozone. Ozone differs from oxygen as regards the number of atoms associated together to form a unit or molecule. The molecule of oxygen consists of two atoms only, but that of ozone contains three, and the greater energy associated with the ozone molecule accounts for the striking difference in its properties. An active variety of nitrogen, very different in properties from ordinary nitrogen, was prepared by Strutt about twelve years ago. This active modification, which can be obtained by subjecting ordinary nitrogen to the action of electric discharges at low pressures, presents even more striking contrasts, as regards chemical activity, with ordinary nitrogen than exist between ozone and ordinary oxygen. Ordinary gaseous nitrogen is an extremely stable substance, requiring fairly high temperatures to undergo interaction with other substances. This great inactivity has been associated with the remarkable stability of the two atoms of nitrogen which constitute the molecule of the gas. The nature of the molecule of active nitrogen is uncertain; it may perhaps consist of a single atom; in any case it must be different from that of ordinary nitrogen.

Results of Changes in Molecular Complexity

We must imagine the molecule of a gas—the least quantity of a gas which can preserve the individuality characteristic of the whole—as an association of elementary atoms in a certain definite proportion. For instance, di-nitrogen tetroxide consists of two atoms of nitrogen associated with four atoms of oxygen to form one unit or molecule of the gas. Now by raising or lowering the temperature of this gas, we can make it break up into two equal units of nitric peroxide, each consisting of one atom of nitrogen and two atoms of oxygen, or to unite again to form the original unit. This change is associated with a remarkable change from the colourless di-nitrogen tetroxide to the dark-brown nitric peroxide. Similarly the unit of iodine up to a temperature of 700° is composed of two atoms of the element; above that temperature the fine violet colour gradually changes as the vapour dissociates into units of one atom, the change being complete at about 1,700°. We see in these cases that a variation in the number of identical atoms associated together in a molecule—which we can refer to briefly as a change in molecular complexity—is associated with remarkable changes in the properties of the substances concerned.

It has been considered legitimate to conclude that the differences in properties of the solid and liquid varieties of substances are also due to differences in molecular complexity, since all well-investigated cases which occur among gases can be explained in this way. Our knowledge of the liquid and solid states of aggregation is, however, very much less advanced than that of the gaseous state. When, therefore, we say that red and white phosphorus differ as regards their molecular condition, we do not specify to what extent they differ; all that we mean is that the remarkable difference in chemical reactivity exhibited by these two varieties of phosphorus must receive an explanation similar to that which accounts for the behaviour of the varieties of substances which are met with in the gaseous state. The crystalline condition of matter is, however, receiving much attention at the present time by the method of X-ray analysis developed by the Braggs during the last few years, and results obtained by this method upon polymorphic substances will be awaited with great interest.

The Transition Point

The temperature at which the solid and liquid phases of a pure substance coexist in stable equilibrium is termed the melting point. In the case of many polymorphic substances (substances existing in more

than one form) there is a similar temperature, termed the transition point. Thus in the case of sulphur, at temperatures below 96° the stable modification is rhombic sulphur; at temperatures above 96°, the stable phase is a different crystalline variety known as monoclinic sulphur. Each of these varieties possesses its own melting point, that of rhombic sulphur being 114·5°, and that of the monoclinic variety being 120°. The transformation of either form into the other is a reversible process at the transition point, just as the transformation of ice into liquid water and *vice versa* is a reversible process. The analogy between a melting point and a transition point is, therefore, remarkably close. There is, however, one important point of difference between them. It is possible to cool a liquid a few degrees below its freezing point without solidification taking place, the liquid being then in what is termed a metastable condition. On the other hand, no one has ever succeeded in heating a solid above its melting point. When we study polymorphic substances, we find that the transition point is, in general, very easily overstepped in both directions, because the rate of transformation of one form into the other is not great. It is for this reason that it is possible to determine the melting point of rhombic sulphur. If the substance is heated fairly quickly, the transition point (96°) is overstepped, and the melting point (114·5°) realised.

An interesting example of a substance which is polymorphic is to be found in the case of tin. As usually met with, this metal is a white crystalline solid. When exposed for long periods of time at somewhat low temperatures, the metal loses its familiar white crystalline appearance, and crumbles to a grey powder. Objects made of this metal, such as old coins or organ pipes in old churches, frequently show signs of what would appear to be corrosion, but what is really transformation of ordinary white tin into the grey variety which is the stable modification at temperatures below 18°. Actually, all tin, except in warm summer weather, is in the metastable condition, but as the transformation into the stable grey powder is so sluggish, objects made of this metal can be preserved for long periods.

Reversibility of Transformation

Substances such as sulphur and tin, whose behaviour is such that the transformation of one form into the other is a reversible process at the transition point, are termed enantiotropic. There is another class of substances which differs from these, in that one form is always less stable than the other; the transformation of that form into the other proceeds in one direction only. Phosphorus is an example of this class of substances. The two best-known forms of phosphorus are the white and the red varieties. Now white phosphorus is always metastable with respect to red. If sticks of white phosphorus are stored in a bottle containing water and exposed to light for long periods, patches of the red variety gradually make their appearance. There is only one way of transforming red phosphorus into the white form, and that is by vaporising the substance and quickly cooling the vapour. When a solid substance is produced from a liquid or vapour it does not, in general, assume the most stable configuration all at once, but first takes up an unstable one, which may remain for a long time before the most stable form is reached. It is in this way that substances such as white phosphorus can be prepared. Substances of this kind are termed monotropic. In the case of enantiotropic substances the transition point lies between the melting point of the two forms; in the case of monotropic substances it is probable that the melting points of both forms are below the transition point.

In the case of both classes of polymorphic substances, the less stable form has always the greater vapour pressure and the greater solubility. This general phenomenon has been found experimentally, but it is only what would necessarily be expected on theoretical grounds. It is not always an easy matter to decide whether two specimens of a substance, which appear to differ in some property, are truly polymorphic. The experimental difficulties of determining the existence or otherwise of a transition point are frequently very considerable. An interesting example is to be found in the case of mercuric oxide. This substance can be obtained in either a yellow or red form, depending upon the method of preparation. Determinations of solubility carried out by electric measurements appear to indicate a slight but distinct difference between the two forms. On this ground, some have concluded that mercuric oxide is polymorphic. Ostwald has, however, pointed out that the solubility determinations do not admit of any conclusion being drawn. It is well known that the solubility of sparingly soluble substances depends upon the size of the particles, that of very small particles being greater than that of larger ones; just as the vapour pressure of small drops is greater than that of larger ones, as was pointed out by Lord Kelvin many years ago. The difference between yellow and red mercuric oxide may be entirely due to the difference in size of the particles.

The Liquid State of Aggregation

The investigation of the liquid state of aggregation from the point of view of polymorphism has yielded many results of interest. Certain organic compounds when heated melt sharply at definite temperatures to

milky liquids, and on being further heated these milky liquids become clear at definite temperatures. When these liquids are cooled, the phenomena are reversed. In addition to their turbid appearance, these milky liquids exhibit strong double refraction, and the term "crystalline liquids" has been applied to them. Much discussion has taken place with reference to the justifiability of this term. Greater interest, perhaps, is attached to liquid sulphur. When sulphur is melted, it fuses to an amber-coloured liquid, but on being further heated, it becomes much darker and more viscous. It has been shown that this phenomenon is due to the fact that liquid sulphur is not a single substance, but a mixture of two different liquids in dynamic equilibrium. The proportion of these two liquid forms varies with the temperature. Smits, who has given much attention to the theoretical aspects of polymorphism, considers that the case of liquid sulphur is to be regarded as one of dynamic allotropy, an idea similar to that of dynamic isomerism (reversible isomeric change), familiar to organic chemists.

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How Upper Winds are Measured

By C. E. Britton, B.Sc.

It is a matter of common observation that clouds often proceed from a different quarter from the wind at the ground, and in most cases appear to be carried along at much greater speed than that of smoke from chimneys. In other words, the speed and direction of the wind in the upper air is often different from the speed and direction of the surface wind. In fact it is very unusual to find the wind at a point 10,000 feet above the ground to be the same, either in direction or speed, as the wind experienced at the same instant on the surface.

Recent Causes effecting Upper Air Investigations

Although this difference in the wind at various heights in the atmosphere has been known for a long time, it is practically only within the last twenty-five years that the velocity of these upper winds has been scientifically measured. At first, upper air investigations were only undertaken by research workers, but, as the importance of the aeroplane came into prominence, measurements of upper winds began to be made at flying schools. It was the Great War, however, which made the continuous and extended observation of the upper atmosphere both necessary and possible. Requests for upper wind readings came from many and various directions. The rapidly increasing bands of aviators required the information; the artilleryman wanted it to ensure accuracy in his firing; the gas warfare departments were equally interested, and it was of the first importance to the sound-rangers. These represented but a few sections of the forces who found of the greatest use the information gleaned by the meteorologists. As a result of this unparalleled expansion, there is now a network of stations in this country where observations of upper winds are made three or four times daily, and the results are embodied by the Air Ministry in a special "Upper Air Supplement of the Daily Weather Report."

Usual Procedure of Investigation

The method of upper wind measurement in general use consists essentially in releasing a small rubber balloon filled with hydrogen and following its subsequent journey by means of a special instrument to measure angles, known as a theodolite. There are several types of balloon used for the purpose, but the one in most common use is made of very thin sheet rubber weighing just over an ounce; it is inflated with hydrogen until its diameter is about 2 feet. The rate of ascent of such balloons in still air has been found to be very nearly uniform, and J. S. Dines [1] has given an empirical formula connecting the rate of ascent with the weight of the balloon and the mass it will just lift when inflated. For the type of balloon mentioned above a velocity of ascent of about 500 feet per minute is obtained, and the usual practice is to adjust the amount of gas put into the balloon so that its rate of ascent, on the basis of the formula, shall be exactly 500 feet per minute.

The flight of these balloons (pilot balloons, as they are called) is watched by an observer through a theodolite designed for this special purpose. These instruments are so designed that the observer is always looking in a horizontal direction, however much the balloon may move about in the sky, and the tangent screws moving the telescope are constructed so that rapid motion can be secured to keep the balloon in the field of view.

The first step in the process of making an observation consists in the setting up of the theodolite. After levelling the instrument, the telescope is sighted upon a prominent object in the landscape, the bearing of which is known, and the scale is revolved until a fixed

[1] *Q.J.R. Met. Soc.*, 1913 and 1918.

mark records the proper direction of the object. The scale is then clamped into position and the instrument is ready to be used for observation.

The second operation is to inflate the balloon. The balloon is weighed and, from the Dines formula, the weight it should just lift, so that the rate of ascent may be 500 feet per minute, is calculated. The balloon is accordingly filled with pure hydrogen from a cylinder of the compressed gas until it just lifts the calculated weight. The orifice in the balloon is sealed and all is ready for the flight.

Generally two observers work together in taking an observation, and, all being ready, one of them releases the balloon and at the same time starts a stop watch. The other sights the balloon in the telescope of the theodolite and follows its motion by moving the two tangent screws in appropriate directions. Exactly at the end of successive minutes the first observer reads the scales of the instrument, and the observation is continued until the balloon is lost to sight. This may occur from many causes. The balloon may enter cloud or haze, or it may burst or be lost in distance. Should the observation terminate by the balloon entering cloud, the height of the cloud becomes very accurately known.

As a result of the observation, the position of the balloon at the end of each minute is known. From these figures it is easy to compute the speed and direction of the wind in each minute and, further, as each successive minute represents an additional 500 feet in altitude, the heights at which the various winds occur are also known. In this way upper winds can be measured up to as great a height as a pilot balloon can be followed through the theodolite. On a clear day, if the wind be not too strong, heights of 40,000 feet are by no means impossible. The necessary calculations can be effected most readily on a special slide rule made by the Air Ministry, and when the balloon is finally lost, the whole of the results are instantly available for use.

A More Accurate Method for Special Uses

It will be at once appreciated that the accuracy of the method is primarily dependent on the uniformity of the rate of ascent of the pilot balloon. Should this depart widely from the theoretical value of 500 feet per minute, the results obtained will be vitiated. On most days the movement of the atmosphere in a vertical direction is small and the error introduced by assuming a steady rise of the balloon is negligible from a practical point of view. For certain investigations, however, it is necessary that uncertainties due to variations in the rate of ascent should be avoided. Thus in experimental gunnery it is important that absolutely accurate values of upper winds should be available. So also in investigating the structure of the atmosphere at great heights ; here the balloon has expanded so much owing to the decreased external pressure that porosity or pin-holes develop and the rate of ascent ceases to be 500 feet per minute. Cases are by no means rare in which the balloon starts to fall, so that calculations based on a uniform rate of ascent will be grossly misleading. To obviate the difficulty, the balloon is followed by two theodolites, one at each end of a measured base line.

The sets of figures thus obtained at the intervals of a minute enable the position of the balloon in space to be fixed, and no assumption as to the rate of ascent has to be made. The method, though of greater accuracy than when only a single theodolite is used, nevertheless demands more personnel, more equipment, and good telephone communication. The amount of computing is also much greater, and the results are not therefore available so quickly. For these reasons this method is not in general use.

A War-time Method

If the speed and direction of the wind at, say, 20,000 feet are required, it will be noted that it would take a pilot balloon 40 minutes to attain this height, provided it did not burst in the meantime. Occasionally, especially during the war, such a wind value was required very quickly, and an ingenious method of effecting this was invented. It consisted in firing a round of anti-aircraft shell with fuse set to burst the shell at the desired height. A puff of smoke was thus produced which was carried along by the wind prevailing at that height. The reflection of this smoke-burst was observed in a horizontal mirror, the observer looking through a fixed peep-sight at a known height above the mirror. The procedure was to make a dot on the mirror where the reflection appeared to be, and then to make a similar dot, say sixty seconds later, in the new position of the burst. The line joining these two dots was thus the path of the reflection as seen in the mirror. Simple mathematics obtain the result that the length between the dots bears the same proportion to the height of the peep-sight above the mirror as the actual distance covered by the smoke burst bears to the height of the burst. As three out of the four terms of this proportion are measurable, the unknown term, namely, the distance travelled by the smoke, becomes immediately calculable. As this distance was covered in sixty seconds, the speed of the wind follows very simply. The wind direction is readily obtained by suitably orienting the mirror.

Should the day be persistently overcast with low cloud, all the foregoing methods are of very little use. Recourse must then be had to very special methods which it is not proposed to deal with in the present

article. What has been said will be sufficient to give the reader an insight into the methods which are used to give the values of the upper winds to be found in the reports and forecasts in the daily Press.

Sunspots and Climate

RECENT discoveries in climatology, in astronomical physics, in geology, and in archæology have been collected together in an amazingly interesting book [1] and utilised to give an explanation of the cause of climatic changes both in geological and in historical time. The book contains information of many kinds, carefully sifted and admirably set forth, in addition to the authors' fertile theories and their deductions therefrom. It illustrates very well the resource, the insight, and the ingenuity of the human mind in face of a difficult problem.

Climatic change in the past has been always an interesting subject. Less than thirty thousand years ago most of our country was under a sheet of ice. At another time its climate was even more genial than that at present. To-day most of Greenland is under ice; it is hard to believe that once coral reefs fringed its shores and palm trees grew on its lands. At one time indeed the climate of the earth seems to have been so equable that many plants and animals could live 1,500 and at other times even 4,000 miles farther from the Equator than now. Changes in wetness have also been great. There are to-day deserts in Asia, even now a feat to cross, which were once so fertile as to support tribes and even contain cities. Nor are these changes confined to the remote past. In the fourteenth century A.D., for instance, it was possible once or twice to cross the Baltic from Germany to Sweden on the ice.

The explanation of these changes and others, less striking but no less interesting, is a very difficult matter. Some, of course, present less difficulty than others. Day-to-day variations of weather are easily explained, and nobody needs to be told more than once why summer is warmer on the average than winter. But why are certain areas every eleven or twelve years subjected to abnormally disturbed weather? Why is something of a similar kind said to occur every thirty-three years? What is at the bottom of the so-called historical pulsations? For example, the twelfth or thirteenth century before Christ was very dry, so were the seventh and the thirteenth of our era if the thickness of the annual rings of the large trees in California and Arizona affords a reliable indication of the amount of moisture available during the period of growth. The fourteenth century A.D., on the other hand, was a time of great climatic severity in many parts of both the Old and the New Worlds which ordinarily have mild climates.

[1] *Climatic Changes. Their Nature and Causes.* By Ellsworth Huntington and Stephen Sargent Visher. (London: Humphrey Milford; New Haven: Yale University Press, 17*s.* 6*d.*)

Much more difficult to give is an explanation of the Ice Age. About 30,000 years ago the Ice Age was at its height in our own country, in parts of North America, but not in corresponding parts of Asia. Why do ice ages occur, and why do they occur, as they appear to do, at irregular intervals? All these and cognate problems are very carefuly stated by the authors of this book before they attempt to solve them. And they have a solution. But before giving it they describe and criticise the hypotheses of climatic change that have been put forward in the past. Each of these, they think, is of importance, but none is really the fundamental one. Variations in the position of the earth when it is nearest the sun, they believe, have a real though slight influence in causing cycles with a length of about 21,000 years. Changes in the amount of the gas carbon dioxide in the air probably have a more important but extremely slow influence on the climate over large periods of time. Variations in the size, shape, and height of the continents are constantly causing all manner of climatic complications. These, however, do not cause rapid fluctuations nor pulsations. The eruption of volcanic dust (which acts as a screen to the sun's rays) appears occasionally to lower the temperature, but it is probable that this cause is less important than many geologists have believed. There is finally the possibility that variation in the position of the poles might be a factor in climatic changes. This theory has been adduced in two main forms. First, the "pendulation" theory, which supposes that the earth's poles swing very slowly backwards and forwards about an axis joining a point in Ecuador with one in Sumatra. Varying distances from the pole, of course, cause changes of climate, "and the movements of the ocean, which adjusts itself to the change of pole more rapidly than the land, causes the great transgressions and regressions of the sea and the elevation and subsidence of the land." Secondly, there is the theory of Wegener,[2] which explains the apparent variation in the position of the pole by the assumption that the earth's crust is moving slowly over the earth's core so that the axis, without necessarily changing its position, passes through different parts of the crust at different epochs.

A simpler and, they believe, a better explanation than any of these is the authors' sunspot hypothesis. This briefly put is as follows: The climate of the earth is regulated by the sun, and consequently varies in harmony with any disturbance in the amount of radiant energy the latter seads out. The times of these disturbances are known because they occur when spots on the sun are visible—a sunspot being a part of the sun's disk where more than the normal amount of energy is poured out. The consequence on the earth of spots on the sun is not, however, as might be imagined, a general rise in temperature. It is more complex than that. For the earth's temperature is conditioned not only by the energy it gets from the sun, but also by the energy it radiates into space. And it is possible, and does, as a fact, happen, that the

[2] For further information on this theory readers are referred to Professor Wegener's article on *The Origin of Continents and Oceans*, DISCOVERY, vol. iii, No. 29.

extra outpouring of energy from sunspots so affects the earth's atmosphere as to make it stormier than usual, with the consequence that the earth's surface is actually cooled. In the past some of these disturbances in the sun have been large, and the earth consequently so affected by them that a glacial epoch has resulted; at other times and more frequently the disturbances have been smaller, and parts of the earth, although profoundly affected, have suffered less. These have been the historical pulsations. More frequent still and of still less force have been the disturbances said to occur every thirty-three years and those more perfectly recognised as occurring every eleven or twelve.

It is the sunspots, the authors believe, which are the fundamental cause of the variations in the earth's climate. They bring about glacial periods, create oceans and mountain ranges, and indeed affect our whole physical environment. The arguments for this cannot be given here. Readers interested in them will find them in the book.

The next question to be asked is: "What causes the sunspots?" That, indeed, is a difficult question. Astronomers declare they do not know But Dr. Huntington and his colleague put forward a very fertile hypothesis. They believe that sunspots—disturbances in the sun's atmosphere—are caused by the conjunction of the planets as well as by the less regular but vastly more disturbing influence of other stars which pass our solar system in their journey through space. It is obvious that changes in the energy emitted by the sun must be due either to a source in the sun or to a source external to it. If it be in the sun we are, so to speak, "done," because no one at the present time can formulate in precise terms a reason therefor; but if the source be outside, we have the whole universe in which to seek a likely cause. Now Jupiter is the largest of the planets, and its changing position with respect to the sun might affect the latter's atmosphere in some way. This way is still open to question, but ignorance of it need not affect the matter. What is of significance is that Jupiter's period of revolution round the sun, 11·86 years, is very nearly that of the sunspot cycle. When, indeed, the effects of Jupiter, Saturn, and the other planets are combined they produce a highly variable curve which has an extraordinary resemblance to the sunspot curve. Because of this the authors accept this planetary hypothesis of sunspots and proceed to develop it. It is known that the climatic difference between sunspot maxima and minima, as measured by temperature, amounts to at least a twentieth and perhaps a tenth of the difference between the climate of the last glacial epoch and the present. From this the authors deduce that a body exerting only four times Jupiter's present tidal effect and placed at the average distance of Jupiter from the sun would so disturb the sun's atmosphere as to make possible a glacial period over the earth.

It is clear that what Jupiter and the other planets may do regularly in, so to speak, a humble way, may be done on a larger scale at irregular intervals by the stars most nearly encountered by the sun in its journey through space. The authors' theory is that a star may influence the sun so as to bring about climatic change on earth in proportion to its size, temperature, and nearness to the sun. The first two of these are fairly constant, but since stars and the sun are moving relatively to each other through space, the third varies. At most times the distances of stars, although variable, are so immense that it may be said the stars have no influence on the sun at all, but there have been times (they can be worked out from astronomical data) when the nearest have been sufficiently near to have, on certain assumptions, a much larger effect than the planets. These times the authors connect with the times of great climatic changes. They show that an average single star would influence the sun enough to cause glaciation on the earth if it came within two hundred thousand million miles of it. They show too that if *a* Centauri, the nearest fixed star to the sun and at present 4·4 light-years distant, came within 1·4 light-years it would produce a glacial epoch. From existing astronomical data the influence of the proximity of the stars to the sun on the climate of the earth can be worked out, and in Chapter XV a curve is given showing the climatic change of 140,000 years (from 68,000 B.C. to A.D. 72,000) so inferred. The curve shows that 70,000 years ago the climate was extremely mild. It gradually became severer, being 45,000 years ago approximately what it is to-day, and became severest about 28,000 years ago. (This agrees very well with the time of the last glacial epoch, which the best authorities put between 25,000 and 30,000 years ago.) The curve shows an amelioration of climate since that time, although it suggests that there is still considerable severity. If we look forward to the 70,000 years ahead we see from the curve that the climate will be, on the whole, very like that of to-day. In that time there will be no return to the very mild climate; likewise there will be no glacial epoch.

These interesting speculations are being developed in a book shortly to be published entitled *Earth and Sun*.

A. S. RUSSELL.

Reviews of Books

PROFESSOR BERGSON'S ATTACK ON INTELLECTUALISM

The Misuse of Mind. By KARIN STEPHEN. With a prefatory letter by HENRI BERGSON. (Kegan Paul, 6*s.* 6*d.*)

The exposition of Professor Bergson's stimulating and disconcerting philosophy is a matter of peculiar difficulty, for he demands that we should put aside our old logical modes of thought and take up a new attitude towards reality, and since language itself was created by the old modes of thought that we are asked to abandon, it follows

that the new attitude finds itself at the outset without a vehicle of expression. The philosophy therefore appears at first to bristle with paradoxes, but these are resolved as the ideas behind them gradually become familiar and the difficulty of the philosophy is found to lie principally in the language in which it must of necessity be expressed.

Professor Bergson's theories are disconcerting because we are not much given to examining the shortcomings of our intellectual processes, being perhaps even a little complacent in the possession of a mental apparatus so much more complex and effective than that of our predecessors in evolution. But if, as we may assume, our mind has been evolved in order to enable us to act efficiently, it is not altogether surprising that we encounter certain difficulties when we apply it to another end—that of knowing for the sake of knowing.

It is perhaps an open question whether the difficulty that we experience in trying to get at the "real truth" of things is due to an inherent incapacity of the intellect, or whether, as Professor Bergson claims, it is due to a faulty habit of thinking; for he points out that we commonly use our mind not in order to know as much as possible, or even to know as accurately as possible, but in order to arrive at a working explanation of the situation with which we are presented. In order to explain the situation, all facts in it are not of equal value to us, but those facts stand out that serve to identify the situation with some previous experience, and enable us to describe it in terms of the already known; any facts that are superfluous to our explanation, or incongruous with it, are liable to be neglected or even unperceived, so that our anxiety to obtain a workable explanation of a situation is liable to limit rather than extend our knowledge of the facts themselves. We may even disregard the facts in favour of some more or less fallacious explanation of them, as when we speak of the "flow" of an electric "current" along a wire. The attitude of Professor Bergson and his followers towards reality may be compared with that of the physicist who is investigating the nature of electricity, and the attitude of the rest of the world towards reality may be compared with that of the electrical engineer who is content to think in terms of volts and ampères.

It has been the disappointing experience of some explorers that primitive races are occasionally less impressed with the unfamiliar mechanisms of our civilisation than one might have hoped. They fail to appreciate them because they are just a little too ready with an explanation, and a gramophone may be quite satisfactorily "accounted for" by them as a superior kind of ventriloquism. Our own attitude towards a new phenomenon is not so very different, and it will probably be admitted that even the most highly civilised individual, when presented with an unfamiliar situation, such as a spiritualistic séance, may be biased in his observation of the facts by the explanation that he applies to them. Professor Bergson holds that this habit of mind is followed not only with the unfamiliar, but also in our everyday "common-sense" attitude, in which we seek not to know the facts, but to construct from a limited selection of them a workable explanation. Thus, in spite of the Scotsman's famous definition of time as "an arbitrary division of the continuous," we are compelled to parcel it out into blocks of seconds, minutes, and hours, and divide it into past, present, and future in order to think of it in a useful way, and therefore we come to miss its real nature, its essential continuity.

This "explanatory" and analytical habit of mind works well enough in the ordinary business of life, but, according to Professor Bergson, it fails us when we employ it in the region of philosophic inquiry since it carries with it a conception of reality built up out of our fallacious explanations of fact and effectively barring any real progress towards the truth. To throw aside our old logical modes of thought requires an heroic mental effort, a kind of intellectual *salto mortale* that threatens to plunge us into the void if we fail to catch the precarious trapeze that Professor Bergson holds out to us and thereby "regain our contact with direct experience"; for we are asked to forgo all classification into mutually exclusive parts, and to treat such ideas as "singular" and "plural," and "past" and "present" as abstractions.

The form of this "direct experience," to which the new attitude of mind should lead us, is described by Professor Bergson as "duration," a process that underlies all change, fusing the elements that change into a synthetic continuum, and thus being in itself essentially creative.

It may be asked whether it is worth while for anyone who is not a professional philosopher to grapple with these difficulties. An answer to this question may be found on p. 99 of Mrs. Stephen's book, where the author says: "If we could overcome this bias [of our habitual mode of thought], we might know more than we do now, though how much more it is not possible, in advance, to predict." Such a promise goes far to explain the wideness of interest that has been evoked by Professor Bergson's philosophy, and contrasts with the faint suspicion of sterility that is attached to the academic philosophies. Even if the reader is unable to accept Professor Bergson's point of view, there is a strong stimulus in his searching criticism of our intellectual methods, of the methods which everyone, whether "plain man" or "intellectual," uses to gain fresh knowledge.

Although Mrs. Stephen's book carries the sub-title of "A Study of Bergson's Attack on Intellectualism," yet it is not the study of a purely destructive criticism, but actually an exposition of the fundamentals of Bergson's philosophy. It is admirably clear, and the author has avoided the technical terms that make most philosophical works so formidable to the average reader. It forms an excellent introduction to the constructive aspect and application of the philosophy, and is made authoritative by a foreword from Professor Bergson in which he says: "The author has been able to unify and present with great logical rigour views which I was obliged by my method of research to treat in isolation."

F. A. Hampton.

(*a*) *The Practical Applications of X-rays.* By G. W. C. KAYE, M.A., D.Sc. (Chapman & Hall, 10*s.* 6*d.*)

(*b*) *The Industrial Applications of X-rays.* By P. H. S. KEMPTON, B.Sc., A.R.C.Sc. (Sir Isaac Pitman & Sons, Ltd., 2*s.* 6*d.*)

(*a*) The first four chapters of Dr. Kaye's book contain a clear, an authoritative, and, in so far as the subject allows, a simple account of the nature, production, and measurement of X-rays. They summarise the existing knowledge on the theoretical side. The fifth chapter describes and illustrates the medical application of the rays, and the sixth their industrial application. How wonderfully the subject of X-rays has been developed in the past twenty-five years! A striking illustration of the advance in technique is shown in the frontispiece: a good radiograph of a hand made in 1896 after an exposure of twenty minutes is shown to compare ill with one made in 1921 with an exposure of one-hundredth of a second. Many of the photographs illustrate practical applications of the rays made by the author during the war years. All are excellent. Among the many radiographs shown are those illustrating defective welds in a steel plate, a foot inside a boot, thumb-prints, a crack in the piston of an aeroplane engine, grub holes, forbidden knots, and splices in aeroplane spars, and the "insides" of many objects like golf-balls, fuses, rifle-grenades, automatic pistols, and alarm clocks. The radiographic method is a terror in revealing defective work, poor materials, and fakes of all kinds. These and other applications are described in the text.

(*b*) Mr. Kempton's book is an introduction to the apparatus and methods used in the production and application of X-rays for the examination of materials and structures. It describes what has been done and what can be done with these rays. It is carefully compiled, always to the point, and suitably illustrated, although it has not the wealth and beauty of the illustrations of Dr. Kaye's book. Like most of Pitman's Technical Primers it is good value for the money.

A. S. R.

The Supremacy of Spirit. By C. A. RICHARDSON, M.A. (Kegan Paul, 5*s.*)

This book is an exposition for general readers of the author's larger work on the same subject. After explaining what philosophy is, and discussing modern philosophies in a clear and interesting manner, he introduces his own views, which are founded on those of Leibniz. To quote Mr. Richardson: "Reality consisted (for Leibniz) in an infinite multitude of individuals, conceived of as unitary, indivisible forces or agents, psychic in nature, to whom he gave the name of 'Monads.'" A development of this point of view leads the author to speak later of the assimilation of food as the introduction of new monads into an organism, which are drilled into the part they have to play by monads already there.

Such a point of view is certainly a novel one to the mere physiologist. Moreover, the author's further comments on the suitability for food of organic substances, highly developed monads, and the unsuitability of inorganic substances, which are more lowly, show that he has not taken into account that inorganic substances play a part in the mechanism of life scarcely second to that of the highly developed "monads" such as boiled beef and cabbage.

The later chapters deal with Spiritualism; in fact the book is designed to lead to a scheme of philosophy in which spiritualism finds a place. It comes as a surprise to read of "Ectoplasm"—a substance which emanates from media in a state of trance, as if its existence in fact were as little disputed as the existence of platinum.

It is of the essence of a true philosophy that it should harmonise all the phenomena of nature. Mr. Richardson's scheme, however, goes even farther—it harmonises all the phenomena of this world and the next and a few which, at least in the opinion of many who have considered them, have no existence in either.

R. J. V. P.

Books Received

(Mention in this column does not preclude a review.)

ANTHROPOLOGY AND ARCHÆOLOGY

The Races of England and Wales. By PROF. H. J. FLEURE, D.Sc. (Benn Bros., Ltd., 5*s.*)

Egypt and the Old Testament. By PROF. T. ERIC PEET, M.A. (Liverpool University Press, Ltd., and Hodder & Stoughton, Ltd., 5*s.*)

History of Roman Religion. By PROF. W. R. HALLIDAY, B.A., B.Litt. (Liverpool University Press, Ltd., and Hodder & Stoughton, Ltd., 5*s.*)

Ancient Man in Britain. By DONALD A. MACKENZIE. With foreword by G. ELLIOT SMITH, F.R.S. (Blackie & Son, Ltd., 12*s.* 6*d.*)

CLASSICAL LANGUAGES AND LITERATURE

The Making of Latin. By PROF. R. S. CONWAY, Litt.D., F.B.A., etc. (John Murray, 5*s.*)

The Claim of Antiquity, with an annotated list of books for those who know neither Latin nor Greek. Issued by the Councils of *The Societies for the Promotion of Hellenic and Roman Studies* and of the *Classical Association.* (Oxford University Press, 1*s.*)

Chanties in Greek and Latin. By W. H. D. ROUSE. (Basil Blackwell, 2*s.* 6*d.*)

A Plain Guide to Greek Accentuation. 3rd Edition, revised. By F. DARWIN SMITH, M.A. (Basil Blackwell, 3*s.*)

MISCELLANEOUS

The Book of Religion and Empire. A Semi-Official Defence and Exposition of Islam written by order

at the Court and with the assistance of the Caliph Muta-Wahkil. (A.D. 847–861.) By 'ALI TABARI. Translated by A. MINGANA, D.D. (Manchester University Press, Longmans, Green & Co., and Bernard Quaritch, Ltd., 10*s.* 6*d.*)

The Outline of History. By H. G. WELLS. The Definitive Edition. Revised and rearranged by the Author. (Cassell & Co., Ltd., 21*s.*)

PSYCHOLOGY

Conditions of Nervous Anxiety and their Treatment. By W. STEKEL. Authorised translation by ROSALIE GABLER. (Kegan Paul, Trench, Trübner & Co., Ltd., 25*s.*)

An Introduction to the Psychology of Religion. By ROBERT H. THOULESS, M.A. (Cambridge University Press, 7*s.* 6*d.*)

Psychology and Politics. By W. H. R. RIVERS, LL.D., F.R.S., etc. With Notes by G. ELLIOT SMITH, F.R.S., and C. S. MYERS, F.R.S. (Kegan Paul, Trench, Trübner & Co., Ltd., 12*s.* 6*d.*)

Conflict and Dream. By W. H. R. RIVERS, LL.D., F.R.S., etc. With Preface by G. ELLIOT SMITH, F.R.S. (Kegan Paul, Trench, Trübner & Co., Ltd., 12*s.* 6*d.*)

SCIENCE

On Certain Pathological Elements in Human Blood. By C. H. COLLINGS.

Glands in Health and Disease. By BENJAMIN HARROW, Ph.D. (George Routledge & Sons, Ltd., 8*s.* 6*d.*)

Biology for Beginners. By TRUMAN J. MOON. (George G. Harrap & Co., 6*s.*)

A very complete survey of Biology, up-to-date and fully illustrated. Although intended for schools, it will be welcomed by many whose interest in natural history is neither compulsory nor utilitarian. The price, when the scope, the numerous illustrations and the wide appeal of this carefully written book are considered, is surprisingly low. One feature, however, deserves comment. The author concludes with a terrible denunciation of alcohol and tobacco—"Tobacco decreases your personal attractiveness. The odour of breath, hands, and perspiration, the stains on fingers and teeth, do not add to your good looks." Tea "sometimes seems to soothe the nerves (which ought not to need soothing)." The book hails from America, and the picture of a biology class studying the tobacco craze calls up surmises of New York classical students at their tasks. Do they, we wonder, discuss chewing gum ?

A Textbook of Inorganic Chemistry. By G. S. NEWTH, F.I.C., F.C.S. (Longmans, Green & Co., 8*s.*)

A new and enlarged edition for 1923 of a long-established and much-used book.

Correspondence

THE DEGENERATION OF FUNCTIONLESS ORGANS

To the Editor of DISCOVERY

SIR,

I have been recently much interested in the phenomena of atrophy and degeneration. The subject is a very debatable one, but, although discussed at length in all works on heredity and evolution, I have never seen any reference to the explanation that I now put forward, and it is on that account that I hope you will find room for this letter in the pages of your excellent journal.

My attention was first attracted to the subject by the weakness of the unsatisfactory explanation to which all the authors on the subject seem to be forced. Take first the case of the abortive wings of certain species of birds which, throughout many generations, have ceased to fly. Most authors strive to explain this on the principles of Natural Selection, saying that those individuals, having an inborn smallness of wing, were able to develop greater leg power and thus tended to be preserved. So far so good, but, as Mr. Watson points out, "In certain cases such an explanation seems undeniably far-fetched. Take the case of the abortive eyes of cave-dwelling fishes." Here then the Natural Selection solution of the problem seems to break down and Mr. Watson, and indeed all other authors on the subject, are forced to the rather weak conclusion that "the inheritance of the effects of disuse is the obvious explanation, and any other must appear both less simple and less probable."

I say that this conclusion is weak because these same authors express disbelief in the uncertain and, indeed, almost certainly imaginary phenomenon of the inheritance of acquired characters. Yet this explanation necessitates a slight acknowledgment of the validity of the phenomenon, for eye-weakness produced by life in the dark is a character acquired after the body- and germ-plasms have become separate. Many biologists have tried to explain away this contradiction by saying that mutilations have only a slight effect on the general system and are not, therefore, inherited, but the effects of disuse burrow deeper and are likely to affect the germ-cells. This does not appear to me to be a solution, but rather an admission of failure to solve. In the first place, the truth of the statement is debatable; secondly, even if we assume it true, why should the disuse of an organ affect only that portion of the germ-plasm representing it, unless we resurrect a theory like the Pangenesis of Darwin—surely the most complicated and least probable theory ever propounded ?

None of these biologists seem to have looked for an explanation in the better-known and more certain process of Natural Selection. Why not ? They seem to regard Natural Selection as a process of elimination only; but why not also a process of retention ? To take the case of the fishes already mentioned. Fish living in the light are dependent on their sight for their safety; consequently Natural Selection has eliminated those individuals

having inborn blindness, thus producing a race with good modal eyesight. Now why should not a reverse process be the cause of partial or complete blindness amongst fishes living in darkness? Those fishes having inborn blindness were just as capable of survival as their comrades having perfect but useless eyes; consequently a process which we might call "Natural Retention" has retained the factor for blindness, and, by constant crossing, the mode of the race in the direction of eye perfection has been reduced. This theory will no doubt be attacked upon the ground that the process would be too slow, but critics in this direction must remember that blindness is a common aberration among animals whose eyes are so primitive in form as those of fishes, and that the factor for blindness would in all probability act as a Mendelian dominant. Also the cave-dwelling fish have been imprisoned for countless generations. The theory has also a great advantage over the "use and disuse" idea in that it can furnish with a satisfactory reply those critics who attack the latter on the question of the Chinese foot-binding practice.

I put as a last example in support of my theory the phenomenon of the absence of pigment from the egg-shells of those birds which habitually lay their eggs in the dark, while those that lay in more or less exposed places usually produce eggs whose shells harmonise in some measure with their surroundings. Natural Selection is the obvious explanation of the latter; but the theory I have just put forward seems to be not only the most probable, but the only explanation of the former. The pigment, unlike an organ of work, vision, or hearing, can hardly be supposed to dwindle from want of use, nor can its disuse be directly appreciated by, or have any mechanical effect on, the embryo bird. To say that those birds which lay pigmentless shells can consequently make a better yolk and albumen and so produce stronger young which tend to be selected is equally absurd. Therefore the conception of "Natural Retention" retaining those birds having a factor for pigmentless shells and, by crossing, ultimately reducing almost to zero the mode of the race in respect to egg-shell pigment, is the only one possible.

Yours, etc.,
GILBERT S. HARTLEY.

BASFORD, STOKE-ON-TRENT.
December 27, 1922.

CLIMATIC CONDITIONS IN THE ROCKIES OF BRITISH COLUMBIA

OUR reviewer of a recent book on climates in the November issue of DISCOVERY has stimulated a correspondent from the Rockies to describe with enthusiasm his own climate. Mr. John Gregg writes from Hudson's Hope, B.C., where only fifty white people inhabit a circle of five miles radius. The temperature there varies from 89° to −50° F.; in the coldest weather there are no winds, in the hottest no flies. He speaks of grizzly bears, moose, goats and sheep for the hunter's delight; but the enthusiast on grizzly bears may be a little diffident in making the journey thither, for it is 250 miles from a railroad. We are glad to hear that, none the less, DISCOVERY managed to get there!

ACROSS THE SAHARA ON MOTOR-CARS

THE recent successful expedition of the Citroën cars across the Sahara has been an interesting and useful experiment. There were nearly two thousand miles of desert to cross; wells were sixty miles apart, and in the centre of the route taken lay the Tanesruft, two hundred miles in length and possibly as desolate an area as any on earth. The camel has hitherto made desert travel possible, and Captain Haywood, who in 1910 travelled the same route as that taken by the expedition, has written in his book, *Timbuctu and the Great Sahara*, of the risks and trials associated with a caravan expedition on camels. Motor transit in ordinary cars is unsatisfactory on account of the nature of the ground travelled over; the back axles frequently break. The caterpillar tread of the cars used in this expedition appears to have proved efficient in overcoming this difficulty.

The expedition followed, for the first two hundred miles of its way, a dried watercourse known as the Wad Mya. Many a British soldier will remember these romantic channels through the desert, carved and moulded like a cavern in the Arabian Nights, where at long intervals a rushing torrent flows when the rains fall—sometimes only once in seven years. In ancient Egypt there was a myth that those who died during each day collected at nightfall by the gate of Tuat, or the other world, which ran, parallel with Egypt, out in the desert. Throughout its length there ran a river, along which there floated the sun-god and the souls of the righteous to the land of Osiris and the great god Rā. To be sure, we paint our heavens to the pattern of our earth, and doubtless the Nile-born Egyptian could not imagine a riverless eternity. But perhaps his conception was helped by the memory of some such desert torrent as that whose course the twentieth-century Citroën adventurers travelled on their way to desert-encircled Timbuctu.

The expedition left Tugurt, the terminus of the railway south of Biskra, on December 18, and reached Timbuctu on January 7. Despite many difficulties on the way, including a sandstorm and an attack by Arab banditti, M. Haardt (Director of the Citroën Factory) and his followers covered the distance at an average of a hundred miles a day.

RAILWAY ELECTRIFICATION

THE author of the article on this subject appearing in our January issue regrets that he made an error in stating the line voltage of the Brighton Railway. Like all single-phase railways, this voltage is considerably above anything practicable with continuous current. The line is at present worked with a line pressure of 6,700 volts and, when further extensions are taken in hand, it will be raised to 11,000 volts. We would also take the opportunity of saying that the paper on "Electric Railway Contact Systems," referred to at the end of the article, is by Sir Philip Dawson, and contains much interesting information as to the results of working with the single-phase system on that railway.